DAkkS Deutsche Akkreditierungsstelle
D-PL-21375-01-03
D-PL-21375-01-04

INGENIEURBÜRO LENHARDT

Bundesnetzagentur
BNetzA-CAB-21/21-21

Test Report

Test report no.: 20114772-18737-0
Date of issue: 2021-08-23

Test result: The test item **- passed -** and complies with the listed standards.

Applicant
Divigraph (Pty) LTD

Manufacturer
Divigraph (Pty) LTD

Test Item
VP2000-01

RF-Spectrum Testing according to:

FCC 47 CFR Part 15
Radio Frequency Devices (Subpart C)

RSS-247
Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

RSS-Gen
General Requirements for Compliance of Radio Apparatus

Tested by (name, function, signature)	*Karsten Geraldy* *Head of Laboratory RF*	signature
Approved by (name, function, signature)	*Dr.-Ing. Harald Ansorge* *Managing Director*	signature

Applicant and Test item details	
Applicant	Divigraph (Pty) LTD 28 Prosperity Park, Computer Road, Milnerton 7441 Cape Town, South Africa Fon: +27 21 065 0344 Fax: +27 86 689 5732
Manufacturer	Divigraph (Pty) LTD 28 Prosperity Park, Computer Road, Milnerton 7441 Cape Town, South Africa
Test item description	Wireless Condition Monitoring
Model/Type reference	VP2000-01
Standard specific information	
FCC ID	2AOADEM51
IC	23417-EM51
PMN	VP2000-01
HVIN	VP2000-01
FVIN	v1
HMN	N/A
Frequency	2.4 GHz ISM band (2400 – 2483.5 MHz)
Technology	IEEE 802.15.4
Antenna	Integrated PCB antenna
Power supply	3.6 V DC via Lithium primary cell (Lithium-Thionyl Chloride)
Temperature range	-40 °C to +85 °C

Disclaimer and Notes

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Within this test report, a ☒ point / ☐ comma is used as a decimal separator.
If otherwise, a detailed note is added adjected to its use.

IBL-Lab GmbH does not take test samples. The sample used for testing is provided by the applicant.

Decision rule: Binary Statement for Simple Acceptance Rule according ILAC-G8:09/2019

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2 GENERAL INFORMATION

2.1 Administrative details

Testing laboratory	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 Sankt Ingbert / Germany Fon: +49 6894 38938-0 Fax: +49 6894 38938-99 URL: www.ib-lenhardt.de E-Mail: info@ib-lenhardt.de
Accreditation	The testing laboratory is accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025:2018. Scope of testing and registration number: • Electronics D-PL-21375-01-01 • Electromagnetic Compatibility D-PL-21375-01-02 • Electromagnetic Compatibility and Telecommunication (FCC requirements) D-PL-21375-01-03 • Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards D-PL-21375-01-04 • ISED Company Number 27156 • Testing Laboratory CAB Identifier DE0020 • Telekommunikation (TK) D-PL-21375-01-05 Website DAkkS: https://www.dakks.de/ The Deutsche Akkreditierungsstelle GmbH (DAkkS) is also a signatory to ILAC Mutual Recognition Arrangement
Testing location	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany
Date of receipt of test samples	2021-03-03
Start – End of tests	2021-03-08 – 2021-06-25

2.2 Possible test case verdicts

Test sample meets the requirements	P (PASS)
Test sample does not meet the requirements	F (FAIL)
Test case does not apply to the test sample	N/A (Not applicable)
Test case not performed	N/P (Not performed)

2.3 Observations

No additional observations other than the reported observations within this test report have been made.

2.4 Opinions and Interpretations

No appropriate opinions or interpretations according ISO/IEC 17025:2017 clause 7.8.7 are within this test report.

2.5 Revision History

-0 Initial Version

2.6 Further documents

List of further applicable documents belonging to the present test report:
- no additional documents -

3 ENVIRONMENTAL & TEST CONDITIONS

3.1 Environmental conditions

Temperature	20°C ± 5°C
Relative humidity	25-75 % r.H.
Barometric Pressure	860-1060 mbar
Power supply	230 V / 50 Hz

3.2 Normal and extreme test conditions

	minimum	nominal	maximum
Temperature	-/-	+22 °C	+50 °C
Relative humidity	-/-	45 % r.h.	-/-
Power supply	-/-	3.6 V DC	-/-

4 TEST STANDARDS AND REFERENCES

Test standard (accredited)	Description
FCC 47 CFR Part 15	Radio Frequency Devices (Subpart C)
RSS-247	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
RSS-Gen	General Requirements for Compliance of Radio Apparatus

Test standard (not accredited)	Description
none	---

Reference	Description
ANSI C63.4-2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
558074 D01 15.247 Meas Guide v05r02	Guidance for compliance measurements on digital transmission systems, frequency hopping spread spectrum systems and hybrid system devices operating under section 15.247 of the FCC rules

5 EQUIPMENT UNDER TEST (EUT)

5.1 Product Description

Wireless Condition Monitoring

*: as declared by applicant

5.2 Test Item Description

Model name*	VP2000-01
Serial number*	radiated EUT: 8190 conducted EUT: 8186
PCB identifier*	N/A
Hardware status*	v5.5
Software status*	FVIN v1

*: as declared by applicant; please see Annex A for EUT photographs.

5.3 Technical Data of Equipment

Operational frequency band*	2.4 GHz ISM band (2400 – 2483.5 MHz)
Technology	IEEE 802.15.4
Modulation type*	DSSS O-QPSK
Data rate*	2 Mb/s
Number of channels*	16
Channel bandwidth*	2 MHz
Channel spacing*	5 MHz
Antenna*	Integrated PCB antenna
Rated RF Output Power*	< 100 mW (20 dBm)
Power supply*	3.6 V DC via Lithium primary cell (Lithium-Thionyl Chloride)
Temperature range*	-40 °C to +85 °C

*: as declared by applicant; further details in clause 5.4.1 of test specification

5.4 Additional Information	
Model differences	none
Ancillaries tested with	none
Additional equipment used for testing	Notebook with test software

5.5 Test modes	
Mode 1	IEEE 802.15.4 compliant radio which modulates a Direct Sequence Spread Spectrum, Offset Quadrature Phase Shift Keying at a chip rate of 2 Mbps. The radio is half-duplex and operates on 10 ms Time Division Multiple Access timeslots.
Low Channel	CH00 = 2405 MHz
Mid Channel	CH07 = 2440 MHz
High Channel	CH15 = 2480 MHz

6 SUMMARY OF TEST RESULTS

Test specification
FCC 47 CFR Part 15 **RSS-247 / RSS-Gen**

Clause	Requirement / Test Case	Result - Remark	Verdict
§15.247(a)(2) RSS-247,5.2 (a)	DTS bandwidth (6 dB)	KDB 558074, clause: 8.2	- PASS -
RSS Gen, 6.7	Occupied bandwidth (99%)	-/-	- PASS -
§15.247(b)(3) RSS-247, 5.4 (d)	RF output power (conducted peak power)	KDB 558074, clause: 8.3.1	- PASS -
§15.247(b)(4) RSS-247, 5.4 (d)	Antenna gain (calculated)	-/-	- PASS -
§15.247(e) RSS-247, 5.2 (b)	Peak power spectral density (PSD)	KDB 558074, clause: 8.4	- PASS -
§15.247(d) RSS-247, 5.5	Band edge compliance (BEC), conducted	KDB 558074, clause: 8.5	- PASS -
§15.247(d) RSS-247, 5.5	Band edge compliance (BEC), radiated	KDB 558074, clause: 8.7	- PASS -
§15.247(d) RSS-247, 5.5	Conducted spurious emissions (CSE)	KDB 558074 DTS clause: 8.5	- PASS -
15.247(d) / §15.209 RSS-247, 5.5 / RSS-Gen, 8.9	Radiated spurious emissions (RSE)	-/-	- PASS -
§15.207 RSS-Gen, 8.8	AC conducted emissions	EUT is battery powered	- N/A -

Comments and observations
Following pages show requirements and references of FCC Part 15.247, ANSI C63.10 and KDB 558074 only. Same tests are also applicable and valid for RSS-247, with clauses given in table above.

7 TEST RESULTS

7.1 DTS Bandwidth (6 dB)

Applicability
This requirement applies to all types of DTS equipment.

Description
The DTS Bandwidth is defined as the 6 dB bandwidth.

Limit
§15.247
(a)(2) The minimum 6 dB bandwidth shall be at least 500 kHz.

Test procedure
ANSI C63.10, 11.8
The steps are as follows:
a) Set RBW = 100 kHz.
b) Set the VBW ≥ [3 × RBW].
c) Detector = peak.
d) Trace mode = max hold.
e) Sweep = auto couple.
f) Allow the trace to stabilize.
g) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.
The automatic bandwidth measurement capability of an instrument may be employed using the 6 dB bandwidth mode.

Test setup: 8.4

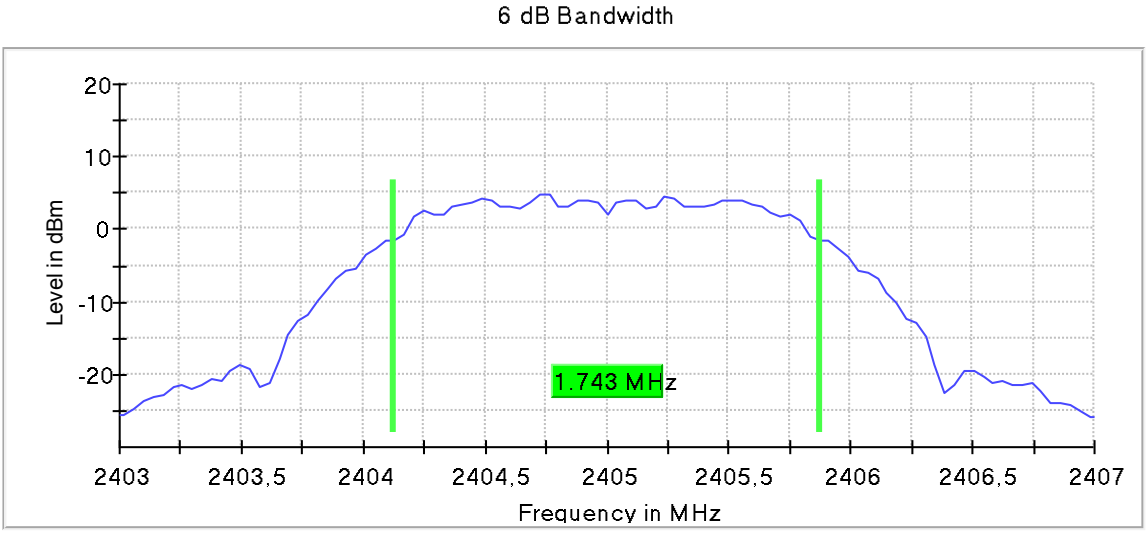
Test Results

EUT Mode	DTS Bandwidth (6 dB)			Limit [kHz]
	low channel [kHz]	mid channel [kHz]	high channel [kHz]	
Mode 1	1743	1743	1743	≥ 500

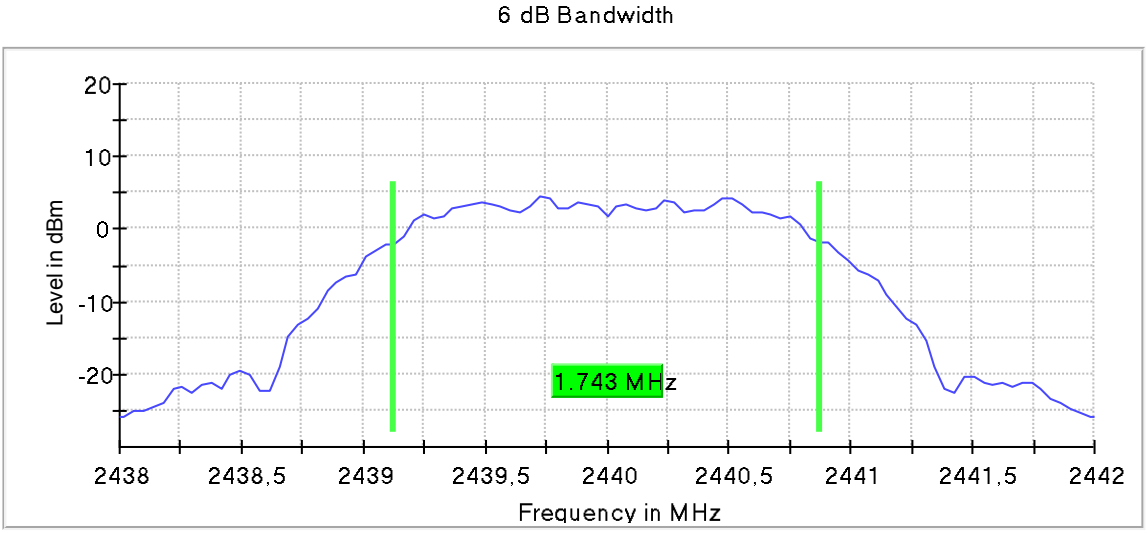
Comment:	---

Verdict	**- PASS -**	*see next plots*

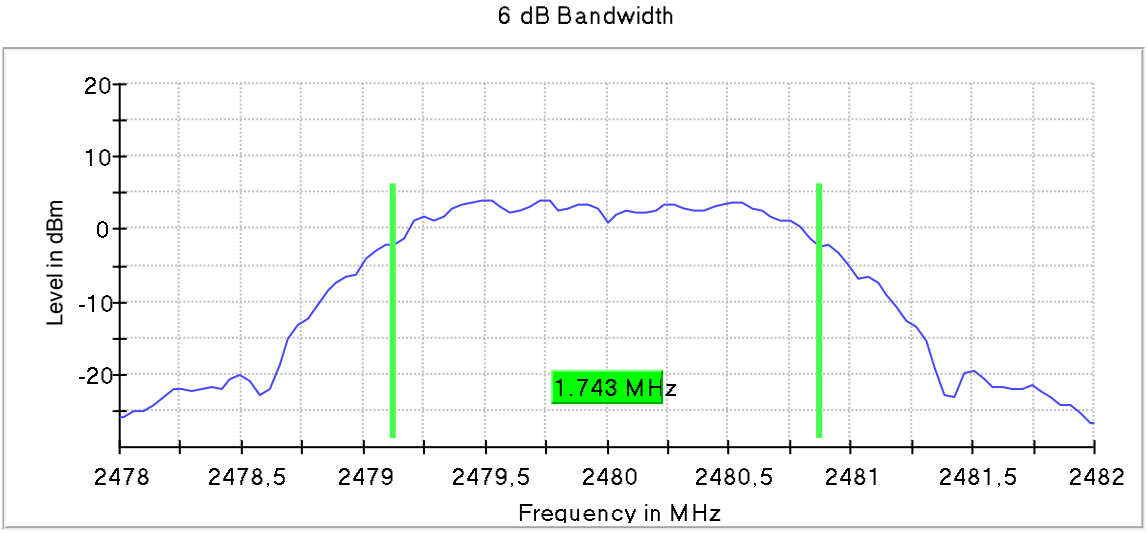
Plot 1: Mode 1, DTS Bandwidth, low channel



Plot 2: Mode 1, DTS Bandwidth, mid channel



Plot 3: Mode 1, DTS Bandwidth, high channel



7.2 Occupied Bandwidth (99% OBW)

Applicability
This requirement applies to all types of DTS equipment.

Description
The Occupied Channel Bandwidth is the bandwidth that contains 99 % of the power of the signal (RSS-Gen).

Limit
No limit defined.

Test procedure
ANSI C63.10, 6.9.3
The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission.
The following procedure shall be used for measuring 99% power bandwidth:
a) The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.
c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.
d) Step a) through step c) might require iteration to adjust within the specified range.
e) Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.
f) Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.
g) If the instrument does not have a 99% power bandwidth function, then the trace data points are recovered and directly summed in linear power terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% power bandwidth is the difference between these two frequencies.

h) The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

Test setup: 8.4

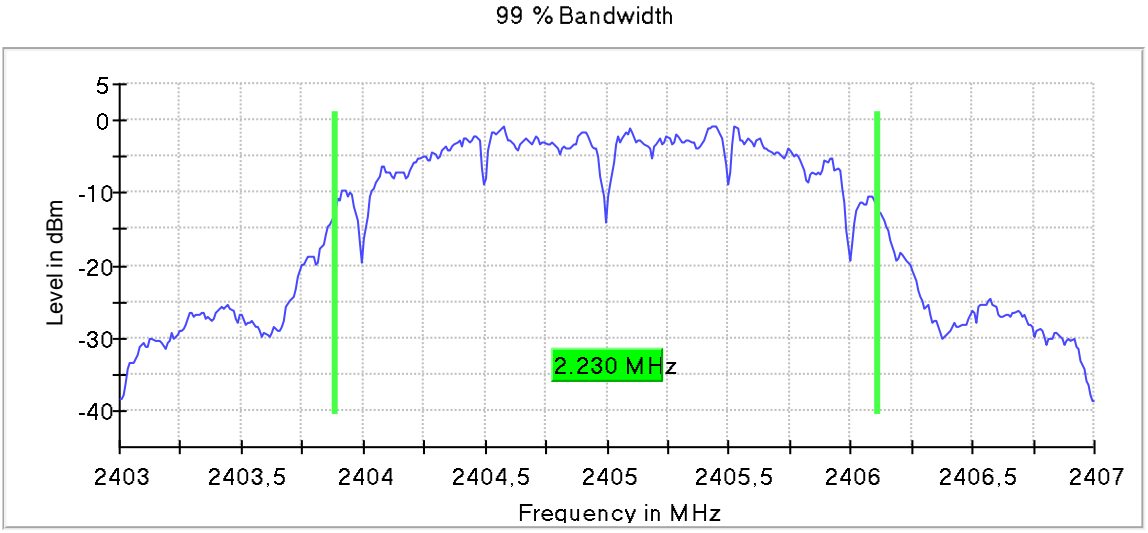
Test Results

EUT Mode	Occupied Bandwidth (99%)		
	low channel [kHz]	mid channel [kHz]	high channel [kHz]
Mode 1	2230	2240	2240

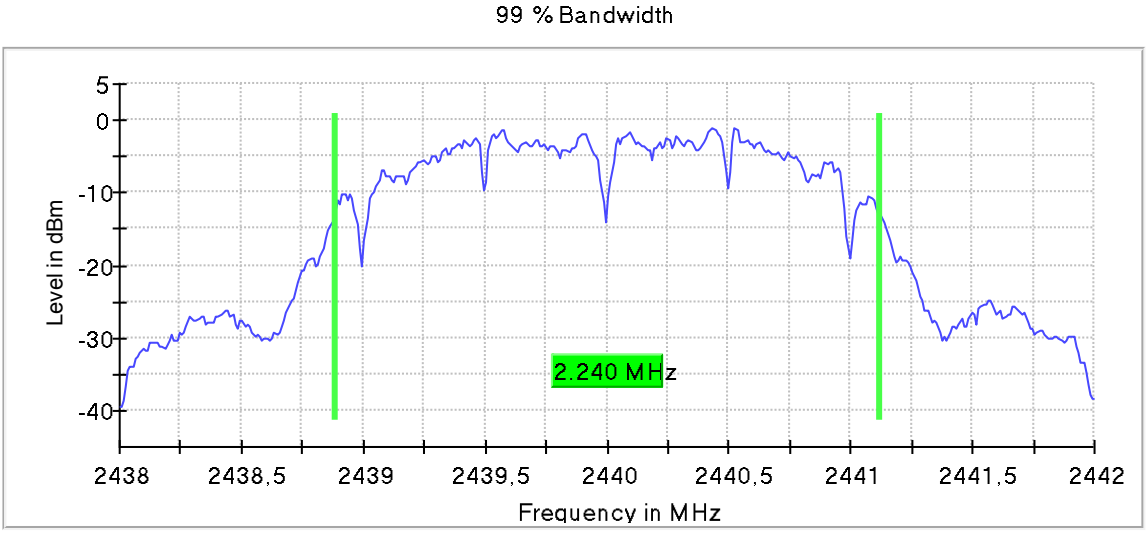
Comment:	---

Verdict	**- PASS -**	*see next plots*

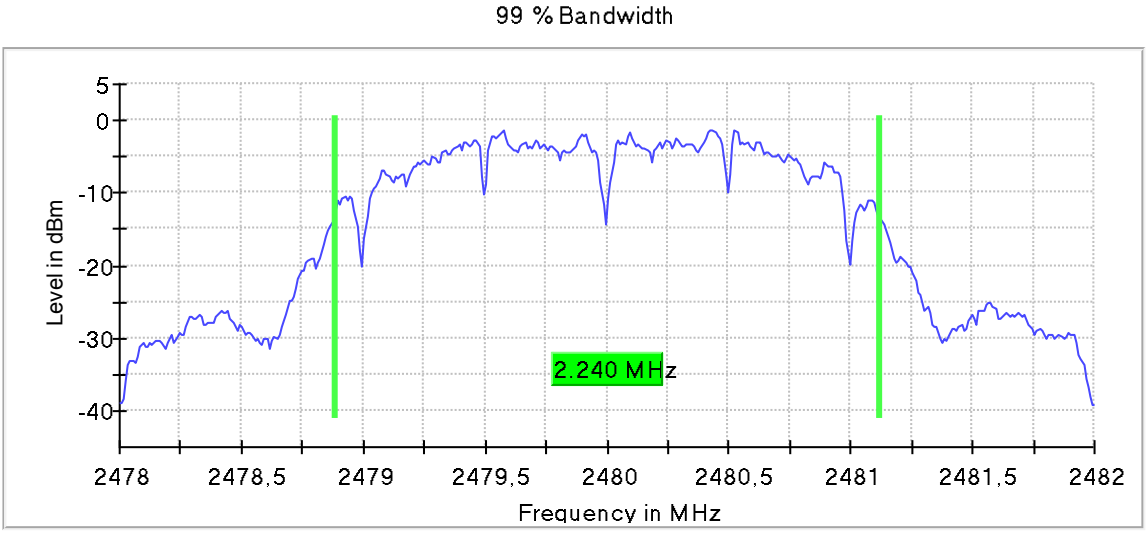
Plot 4: Mode 1, 99% Occupied Bandwidth, low channel



Plot 5: Mode 1, 99% Occupied Bandwidth, mid channel



Plot 6: Mode 1, 99% Occupied Bandwidth, high channel



7.3 RF Output Power (Conducted Peak Power)

Applicability
This requirement applies to all types of DTS equipment.

Description
The RF Output Power is defined as the conducted peak output power.

Limit
§15.247
(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.
(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi.

Test procedure
ANSI C63.10, 11.9.1.1
The following procedure shall be used when an instrument with a resolution bandwidth that is greater than the DTS bandwidth is available to perform the measurement:
a) Set the RBW ≥ DTS bandwidth.
b) Set VBW ≥ [3 × RBW].
c) Set span ≥ [3 × RBW].
d) Sweep time = auto couple.
e) Detector = peak.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use peak marker function to determine the peak amplitude level.

Test setup: 8.4

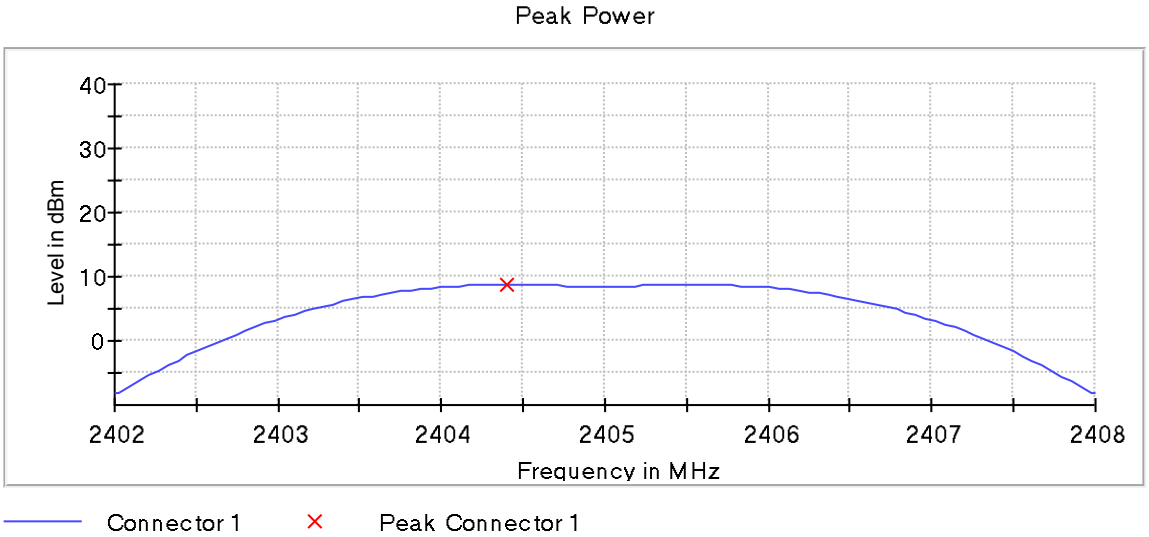
Test Results

EUT Mode	RF Output Power (Conducted Peak Power)			Limit [dBm]
	low channel [dBm]	mid channel [dBm]	high channel [dBm]	
Mode 1	8.7	8.3	8.2	30

Comment:	---

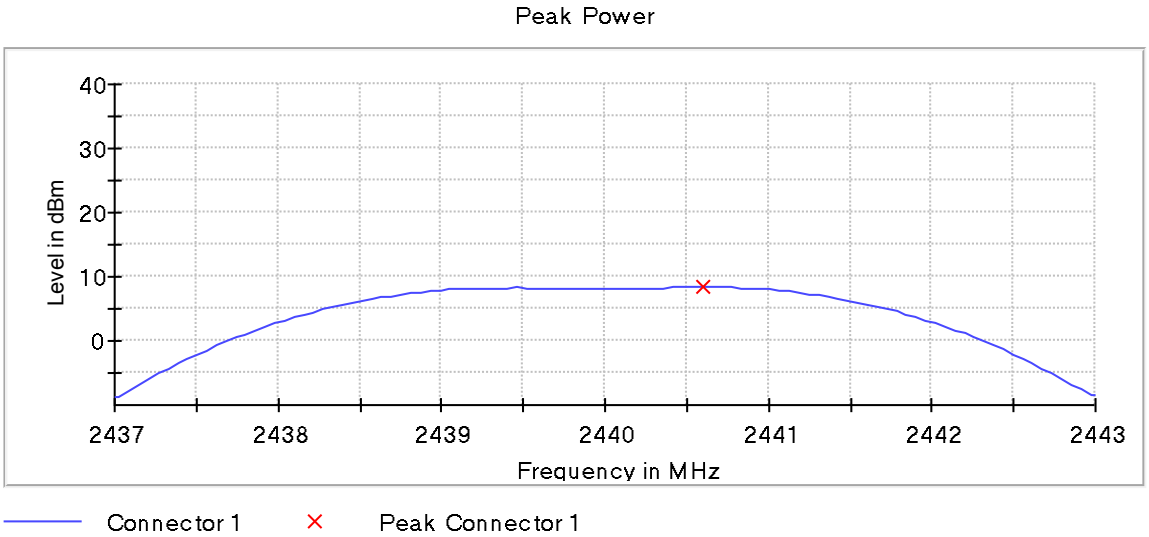
Verdict	**- PASS -**	*see next plots*

Plot 7: Mode 1, Peak Power, low channel



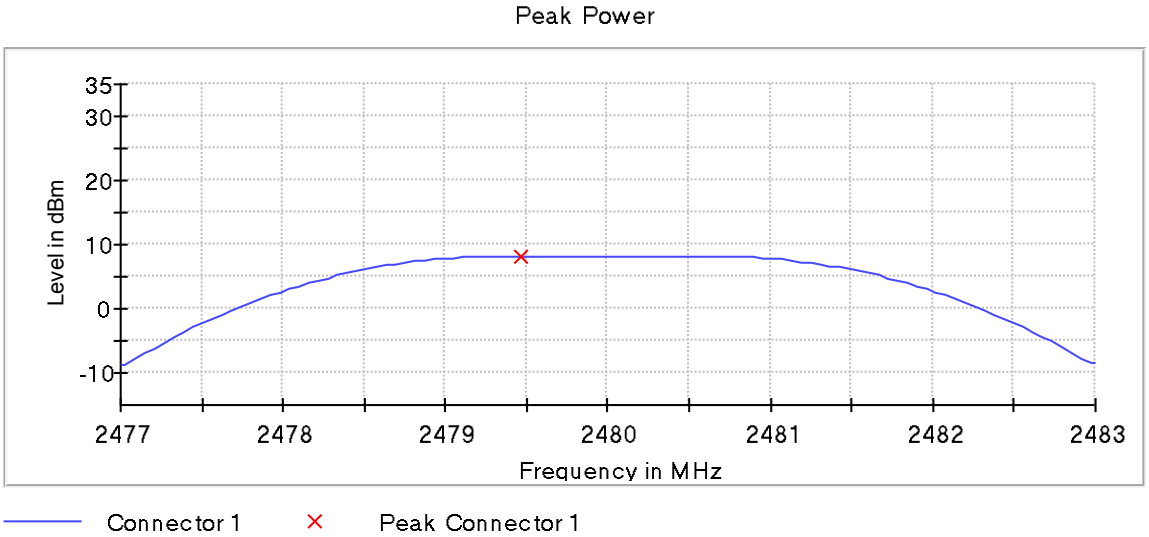
DUT Frequency (MHz)	Peak Power (dBm)	Limit Max (dBm)	Result
2405.000000	8.7	30.0	PASS

Plot 8: Mode 1, Peak Power, mid channel



DUT Frequency (MHz)	Peak Power (dBm)	Limit Max (dBm)	Result
2440.000000	8.3	30.0	PASS

Plot 9: Mode 1, Peak Power, high channel



DUT Frequency (MHz)	Peak Power (dBm)	Limit Max (dBm)	Result
2480.000000	8.2	30.0	PASS

7.4 Antenna Gain (calculated)

Applicability
This requirement applies to all types of DTS equipment.

Description
The antenna gain is defined as the difference between radiated peak power (Peak EIRP) substracted by the conducted peak power of the module, given in dBi.

Limit
§15.247
(b)(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi.

Test setup: 8.2, 8.4

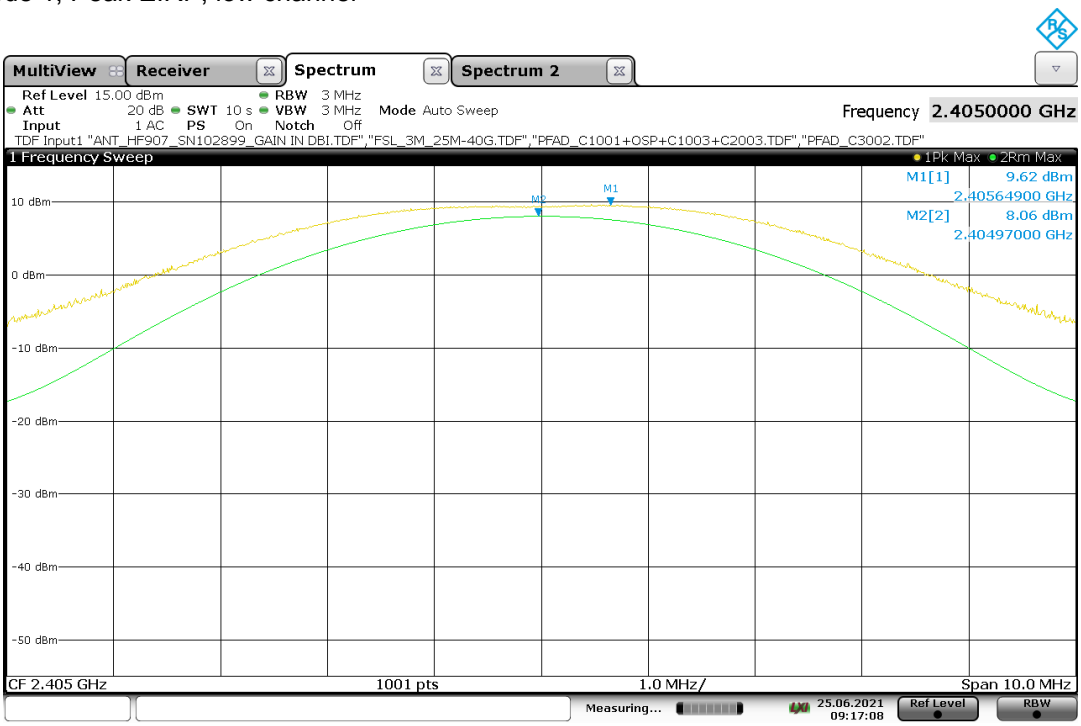
Test Results

Mode 1	low channel	mid channel	high channel	Limit
Radiated peak power [dBm]	9.6	11.0	9.3	36
Conducted peak power [dBm]	8.7	8.3	8.2	30
Calculated antenna agin [dBi]	0.9	2.7	1.1	6

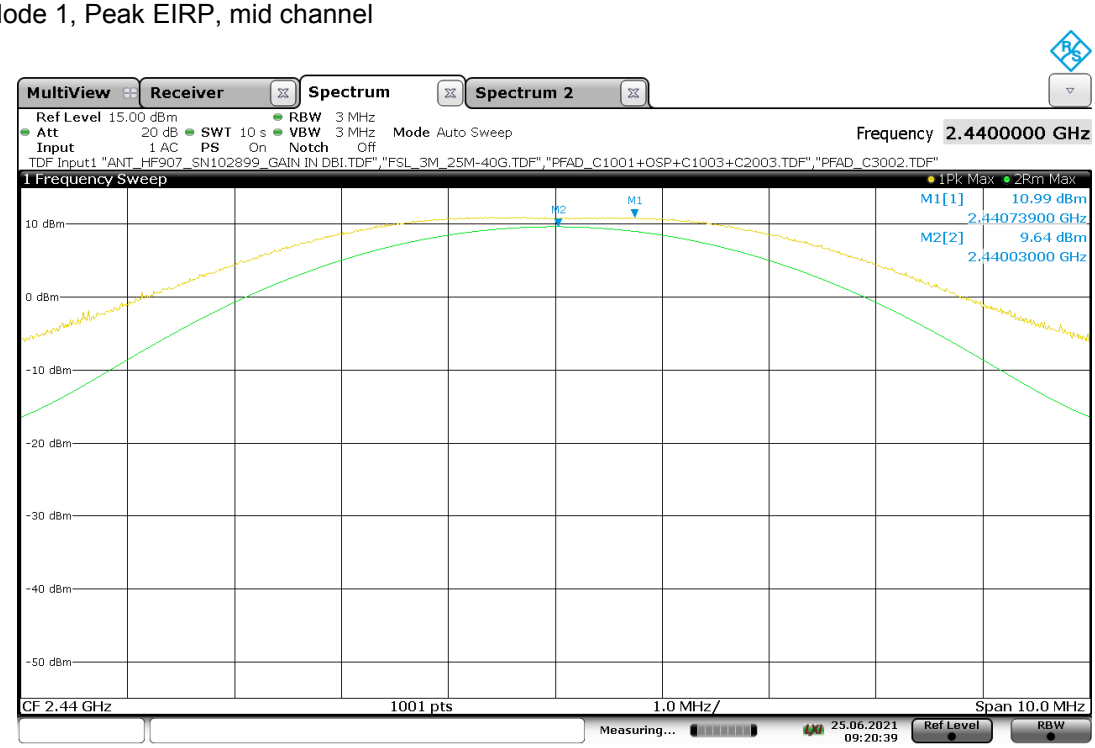
Comment:	---

Verdict	**- PASS -**	

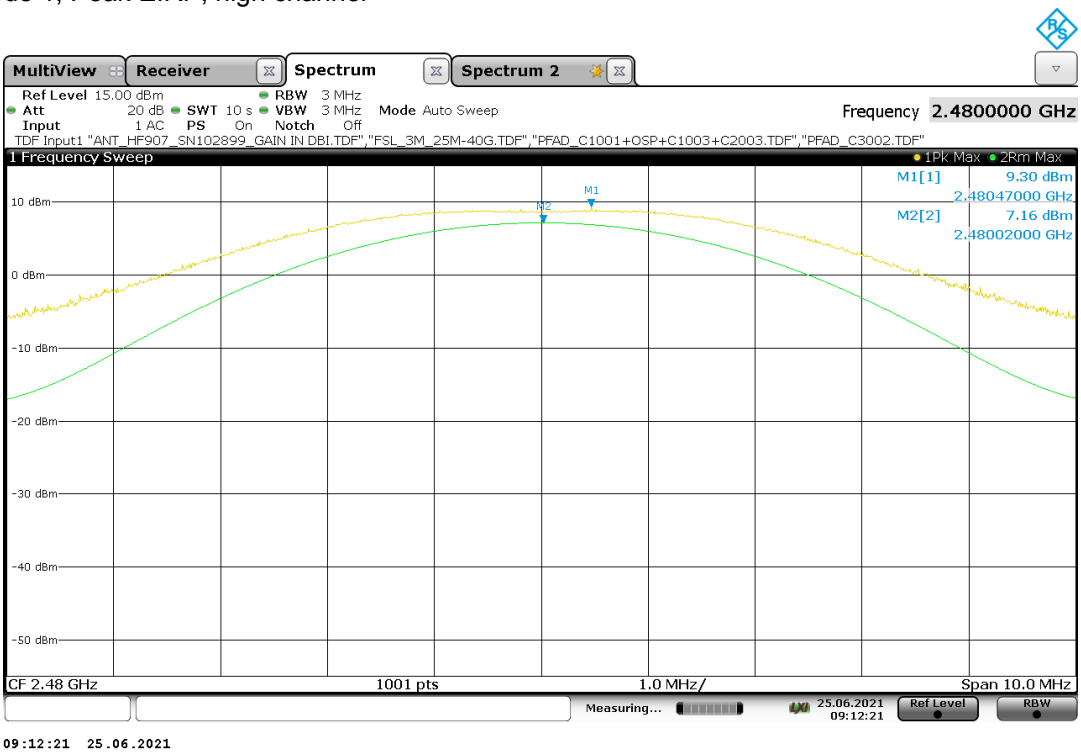
Plot 10: Mode 1, Peak EIRP, low channel



Plot 11: Mode 1, Peak EIRP, mid channel



Plot 12: Mode 1, Peak EIRP, high channel



7.5 Peak Power Spectral Density (PSD)

Applicability
This requirement applies to all types of DTS equipment.

Description
The Power Spectral Density (PSD) is defined as the conducted peak power spectral density in a 3 kHz bandwidth during any time of continuous transmission.

Limits
§15.247
(e) For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

Test procedure
ANSI C63.10, 11.10.2
The following procedure shall be used if maximum peak conducted output power was used to determine compliance, and it is optional if the maximum conducted (average) output power was used to determine compliance:
a) Set analyzer center frequency to DTS channel center frequency.
b) Set the span to 1.5 times the DTS bandwidth.
c) Set the RBW to 3 kHz ≤ RBW ≤ 100 kHz.
d) Set the VBW ≥ [3 × RBW].
e) Detector = peak.
f) Sweep time = auto couple.
g) Trace mode = max hold.
h) Allow trace to fully stabilize.
i) Use the peak marker function to determine the maximum amplitude level within the RBW.
j) If measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat.

Test setup: 8.4

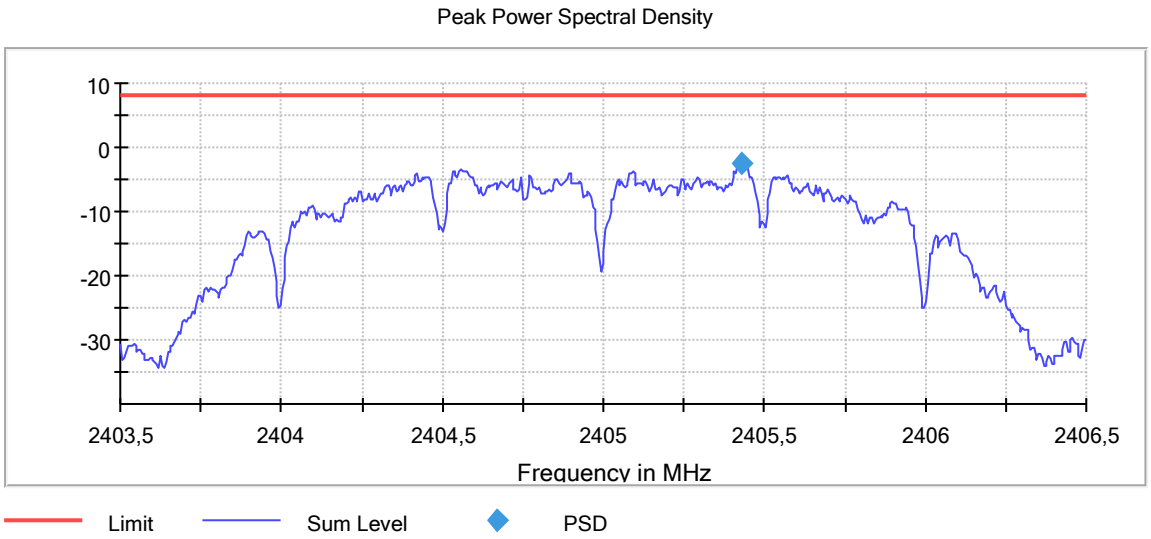
Test Results

EUT Mode	Peak Power Spectral Density [dBm / 3 kHz]			Limit [dBm / 3 kHz]
	low channel	mid channel	high channel	
Mode 1	-2.1	-2.4	-2.8	8

Comment:	---

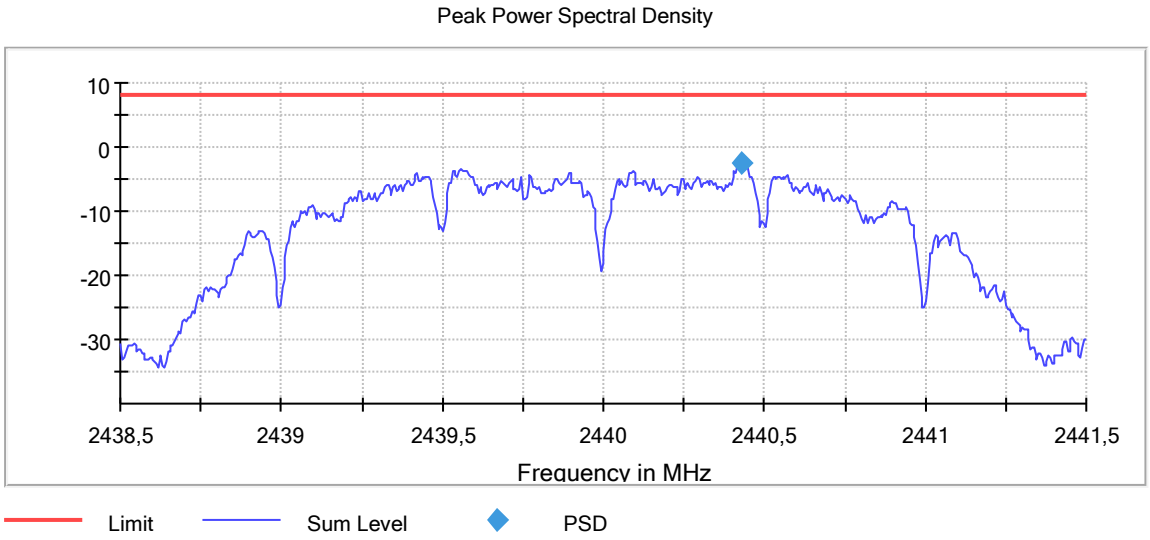
Verdict	**- PASS -**	*see next plots*

Plot 13: Mode 1, Peak PSD, low channel



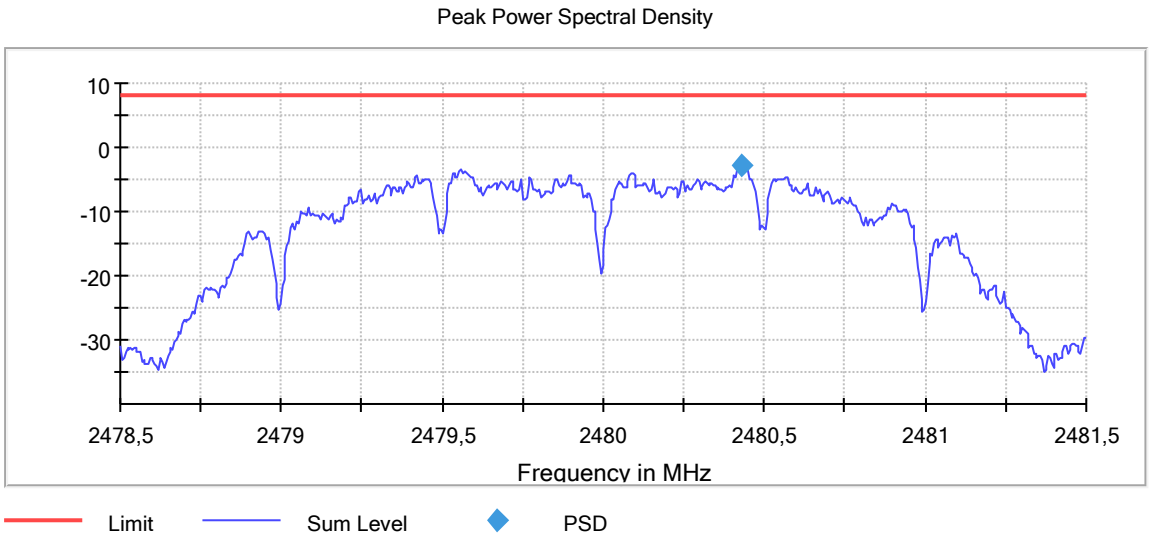
DUT Frequency (MHz)	Frequency (MHz)	PSD (dBm)	Limit Max (dBm)	Result
2405.000000	**2405.432500**	**-2.133**	**8.0**	**PASS**

Plot 14: Mode 1, Peak PSD, mid channel



DUT Frequency (MHz)	Frequency (MHz)	PSD (dBm)	Limit Max (dBm)	Result
2440.000000	**2440.432500**	**-2.405**	**8.0**	**PASS**

Plot 15: Mode 1, Peak PSD, high channel



DUT Frequency (MHz)	Frequency (MHz)	PSD (dBm)	Limit Max (dBm)	Result
2480.000000	**2480.432500**	**-2.751**	**8.0**	**PASS**

7.6 Band Edge Compliance (BEC), conducted

Applicability
This requirement applies to all types of DTS equipment.

Description
Emissions within a restricted band and within 2 MHz of an authorized band edge may be measured using either the marker-delta method (ANSI C63.10, 6.10.6) or the integration method (ANSI C63.20, 11.13.3), provided that the DTS bandwidth (or EBW) edge falls within 2 MHz of the band edge. Otherwise, all unwanted emissions measurements shall be performed using the standard methods.

Limits
§15.247
(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. Attenuation below the general limits specified in §15.209(a) is not required.

Test procedure
ANSI C63.10, 11.11
Reference level measurement:
Establish a reference level by using the following procedure:
a) Set instrument center frequency to DTS channel center frequency.
b) Set the span to ≥ 1.5 times the DTS bandwidth.
c) Set the RBW = 100 kHz.
d) Set the VBW ≥ [3 × RBW].
e) Detector = peak.
f) Sweep time = auto couple.
g) Trace mode = max hold.
h) Allow trace to fully stabilize.
i) Use the peak marker function to determine the maximum PSD level.
Note that the channel found to contain the maximum PSD level can be used to establish the reference level.

Emission level measurement:
Establish an emission level by using the following procedure:
a) Set the center frequency and span to encompass frequency range to be measured.
b) Set the RBW = 100 kHz.
c) Set the VBW ≥ [3 × RBW].
d) Detector = peak.
e) Sweep time = auto couple.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use the peak marker function to determine the maximum amplitude level.
Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) is attenuated by at least the minimum requirements as specified (≥ 20 dBc).

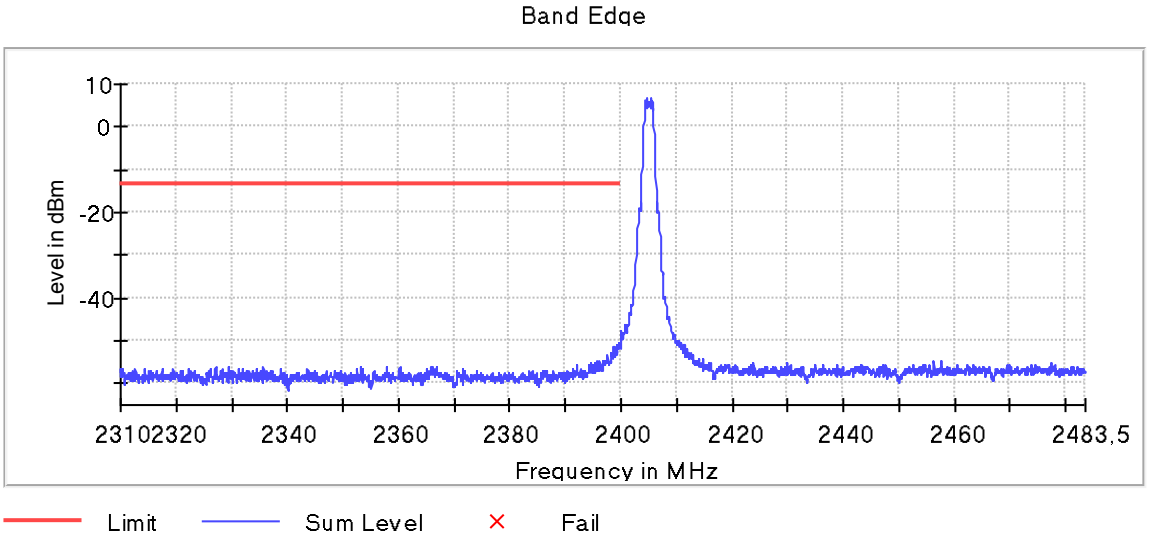
The marker-delta method, as described in ANSI C63.10, 6.10.6 can be used to perform measurements of the radiated unwanted emissions level at the band-edges provided that the 99 % OBW of the fundamental emission is within 2 MHz of the authorized band edge.

Test setup: 8.4			
Test results			
BEC	**low channel [dBc]**	**high channel [dBc]**	**Limit [dBc]**
Mode 1	> 50	> 55	≥ 20

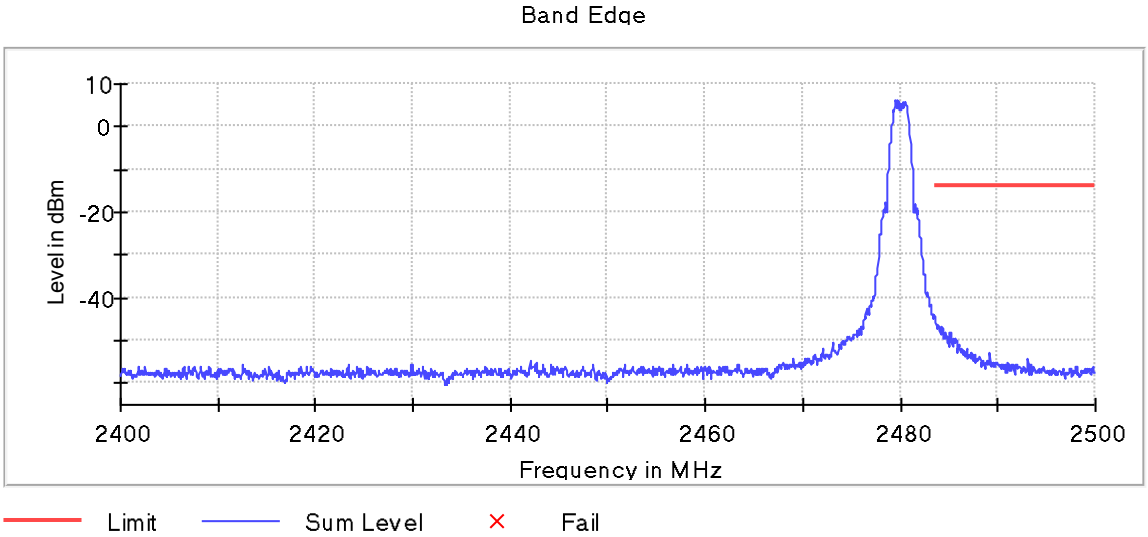
Comment:	---

Verdict	**- PASS -**	*see next plots*

Plot 16: Mode 1, BEC, low channel



Plot 17: Mode 1, BEC, high channel



7.7 Band Edge Compliance (BEC), radiated

Applicability
This requirement applies to all types of DTS equipment.

Description
Emissions within a restricted band and within 2 MHz of an authorized band edge may be measured using either the marker-delta method (ANSI C63.10, 6.10.6) or the integration method (ANSI C63.20, 11.13.3), provided that the DTS bandwidth (or EBW) edge falls within 2 MHz of the band edge. Otherwise, all unwanted emissions measurements shall be performed using the standard methods.

Limits
§15.247
(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Test procedure
The marker-delta method as described in ANSI C63.10, 6.10.6 or the integration methode as described in ANSI C63.10, 11.13.3 can be used to perform measurements of the unwanted emissions level at the band edges.

Test setup: 8.2

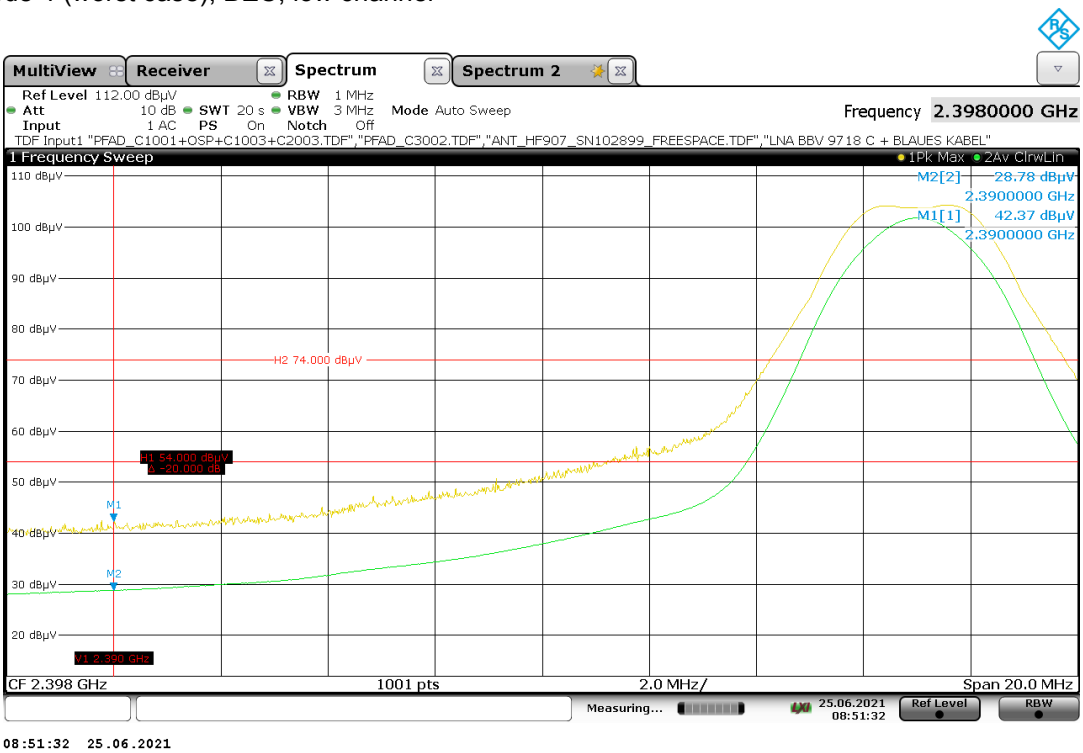
Test results

BEC	low channel AVG / Peak [dµV/m @3m]	high channel AVG / Peak [dµV/m @3m]	Limit AVG / Peak [dµV/m @3m]
Mode 4 (worst case)	28.8 / 42.4	50.0 / 62.9	≤ 54 AVG / ≤ 74 PK

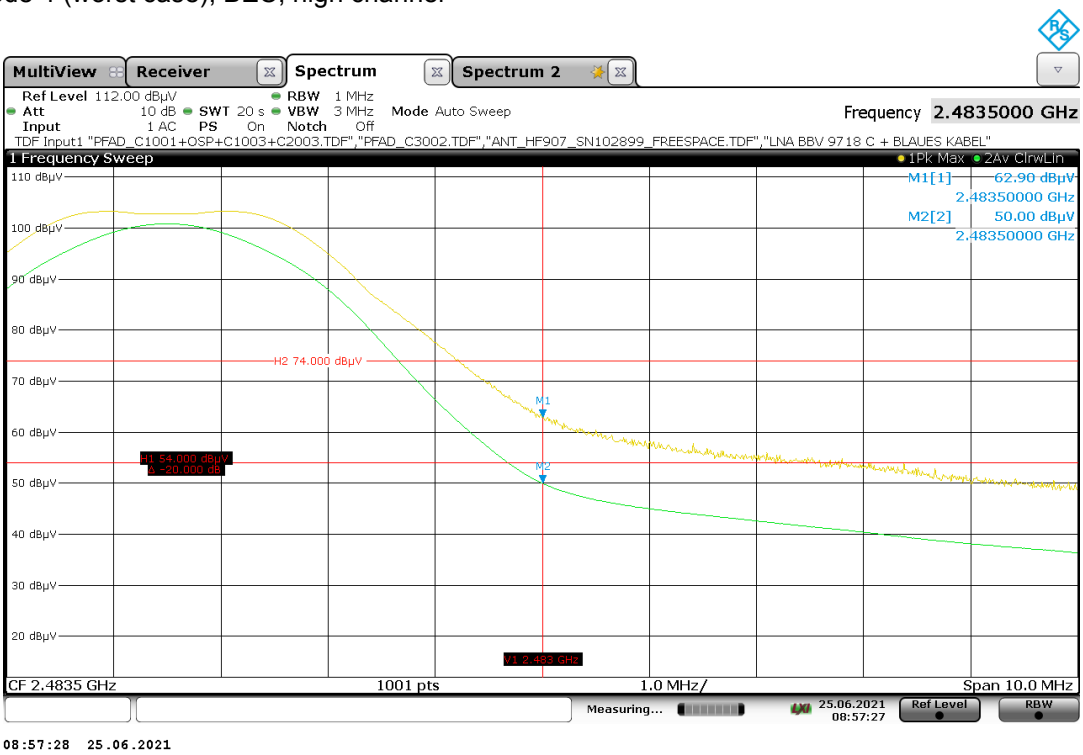
Comment:	---

Verdict	- PASS -	*see next plots*

Plot 18: Mode 4 (worst case), BEC, low channel



Plot 19: Mode 4 (worst case), BEC, high channel



7.8 Conducted Spurious Emissions (CSE)

Applicability
This requirement applies to all types of DTS equipment.

Description
Spurious emission / unwanted emissions are emission on a frequency or frequencies which are outside the authorized band and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products.

Limits
§15.247
(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. Attenuation below the general limits specified in §15.209(a) is not required.

Test procedure
ANSI C63.10, 11.11
Reference level measurement:
Establish a reference level by using the following procedure:
a) Set instrument center frequency to DTS channel center frequency.
b) Set the span to ≥ 1.5 times the DTS bandwidth.
c) Set the RBW = 100 kHz.
d) Set the VBW ≥ [3 × RBW].
e) Detector = peak.
f) Sweep time = auto couple.
g) Trace mode = max hold.
h) Allow trace to fully stabilize.
i) Use the peak marker function to determine the maximum PSD level.
Note that the channel found to contain the maximum PSD level can be used to establish the reference level.

Emission level measurement:
Establish an emission level by using the following procedure:
a) Set the center frequency and span to encompass frequency range to be measured.
b) Set the RBW = 100 kHz.
c) Set the VBW ≥ [3 × RBW].
d) Detector = peak.
e) Sweep time = auto couple.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use the peak marker function to determine the maximum amplitude level.
Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) is attenuated by at least the minimum requirements as specified (≥ 20 dBc).

The marker-delta method, as described in ANSI C63.10, 6.10.6 can be used to perform measurements of the radiated unwanted emissions level at the band-edges provided that the 99 % OBW of the fundamental emission is within 2 MHz of the authorized band edge.

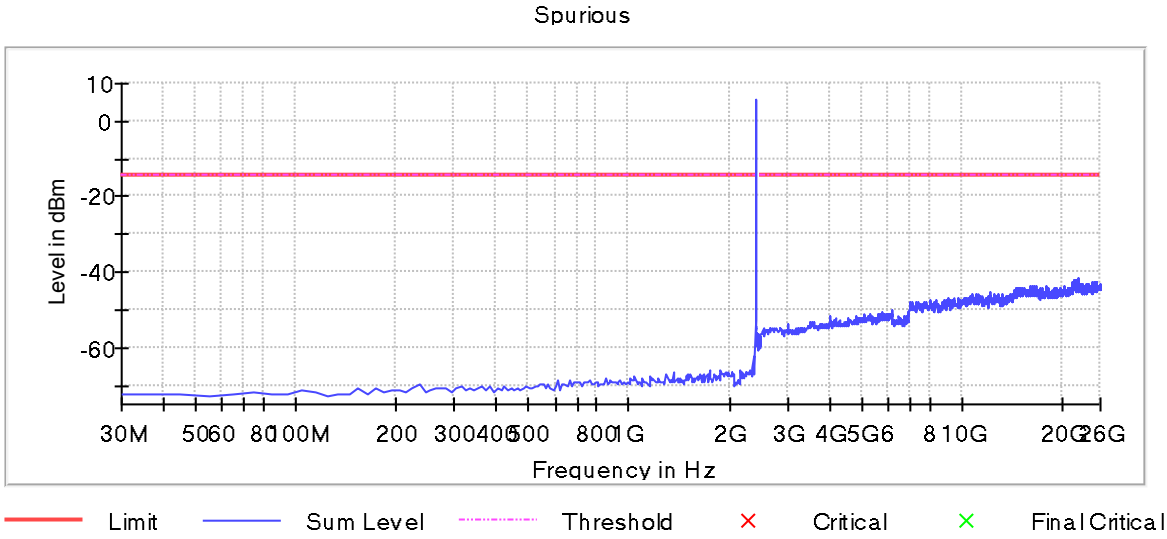
Test setup: 8.4					
Test results					
EUT Mode / Channel	**Frequency [MHz]**	**Peak/RMS Detector**	**Level [dBm]**	**Limit [dBm]**	**Verdict**
(see plots)	*(see plots)*	*(see plots)*	*(see plots)*	*(see plots)*	- passed -
(see plots)	*(see plots)*	*(see plots)*	*(see plots)*	*(see plots)*	- passed -
(see plots)	*(see plots)*	*(see plots)*	*(see plots)*	*(see plots)*	- passed -

* all detected peaks are more thean 6 dB below the limit

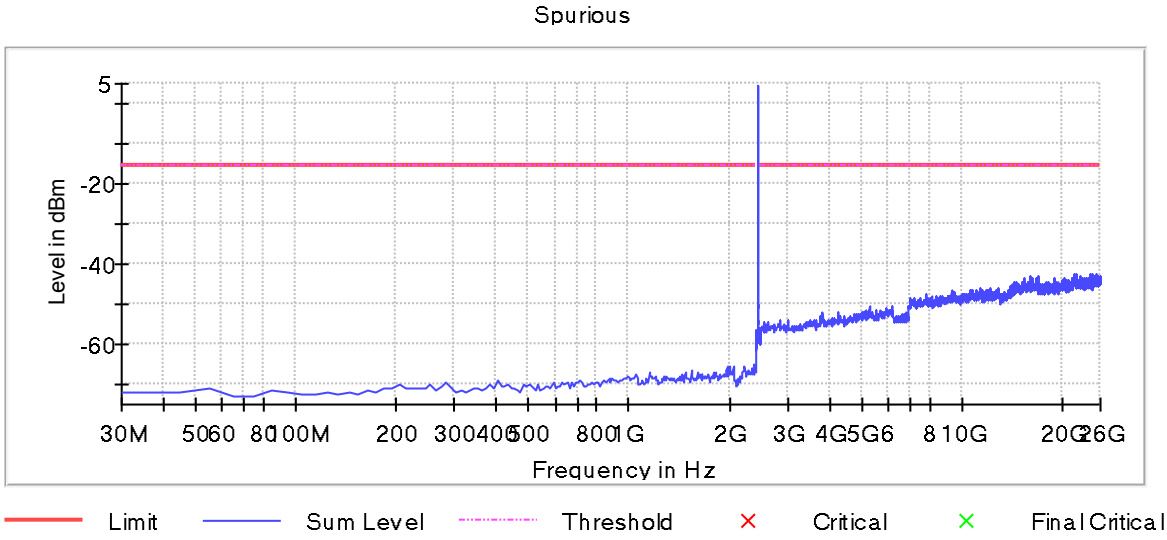
Comment:	---

Verdict	**- PASS -**	*see next plots*

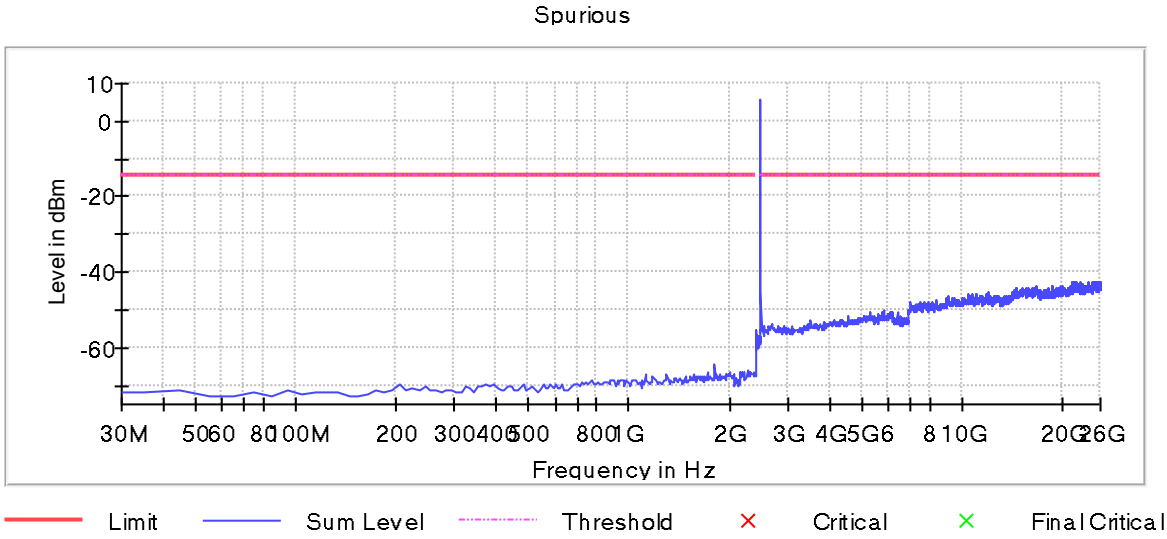
Plot 20: Mode 1, CSE, low channel



Plot 21: Mode 1, CSE, mid channel



Plot 22: Mode 1, CSE, high channel



7.9 Radiated Spurious Emissions (RSE)

Applicability
This requirement applies to all types of DTS equipment.

Description
Spurious emission / unwanted emissions are emission on a frequency or frequencies which are outside the authorized band and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products. Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation.

Limits
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 [µV/m] / [dBµV/m]	Measurement distance [m]
0.009 – 0.490	2400/F[kHz]	300
0.490 – 1.705	24000/F[kHz]	30
1.705 – 30.0	30.0 / 29.5	30
30 – 88	100 / 40.0	3
88 – 216	150 / 43.5	3
216 – 960	200 / 46.0	3
960 – 40 000	500 / 54.0	3

Note
Radiated Spurious Emissions (RSE) are performed for low / mid / high channel and modulation with the highest output power (worst case). In case of spurious other modulations are spot-checked.

Test setup: 8.1, 8.2, 8.3

Test results

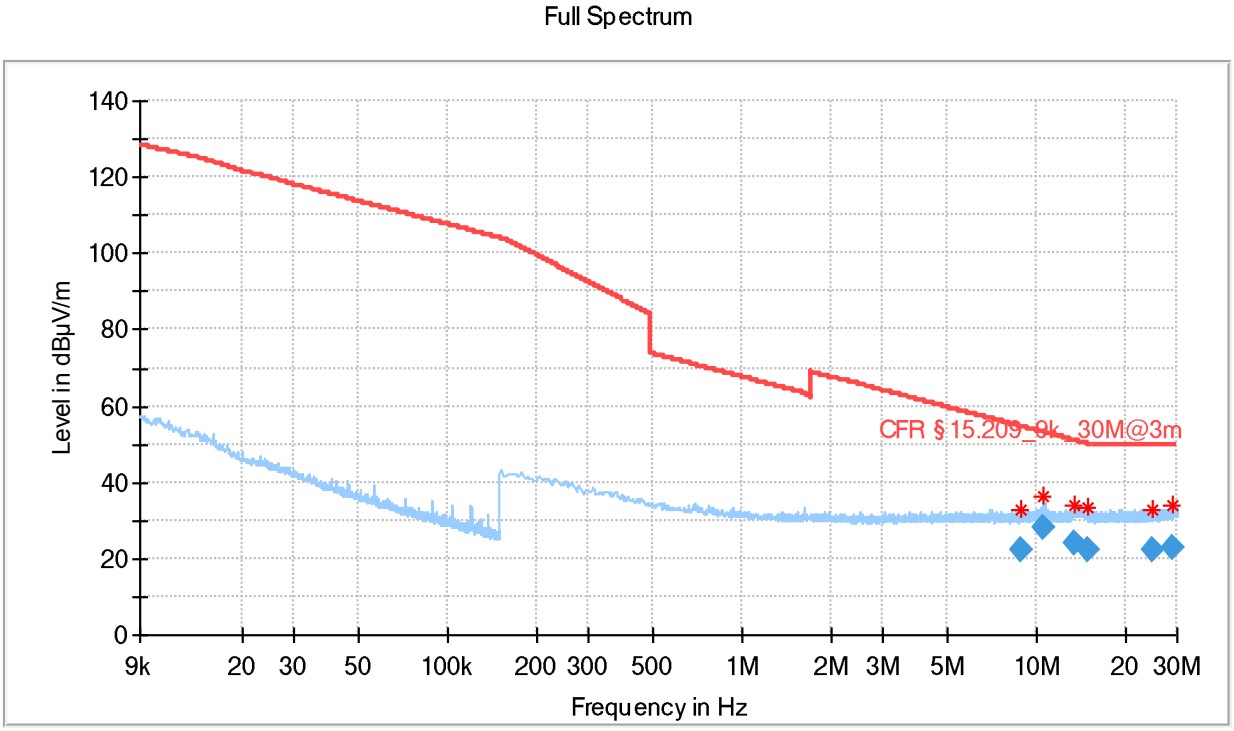
EUT Mode / Channel	Frequency [MHz]	Peak/RMS Detector	Level [dBm]	Limit [dBm]	Verdict
(see plots)	*(see plots)*	*(see plots)*	*(see plots)*	*(see plots)*	- passed -
(see plots)	*(see plots)*	*(see plots)*	*(see plots)*	*(see plots)*	- passed -

* all detected peaks are more thean 6 dB below the limit

Comment:	---

Verdict	**- PASS -**	*see next plots*

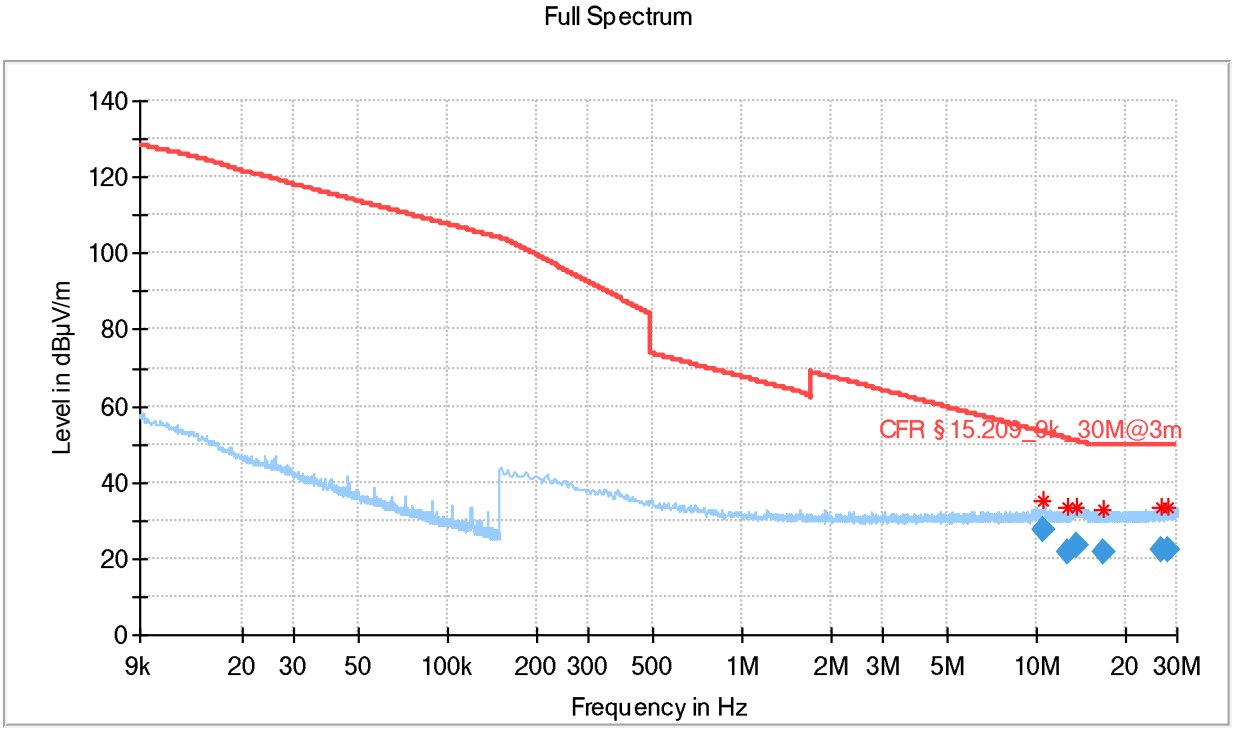
Plot 23: Mode 1, RSE 9 kHz – 30 MHz, low channel, loop antenna



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Azimuth (deg)	Corr. (dB/m)
8.817000	22.08	54.68	32.60	15000.0	9.000	120.0	20.5
10.578750	27.89	53.10	25.21	15000.0	9.000	300.0	20.5
13.431750	24.08	51.02	26.95	15000.0	9.000	180.0	20.5
14.903250	22.12	50.12	28.00	15000.0	9.000	180.0	20.5
24.663750	22.38	49.54	27.16	15000.0	9.000	180.0	20.6
29.145750	22.76	49.54	26.78	15000.0	9.000	300.0	20.8

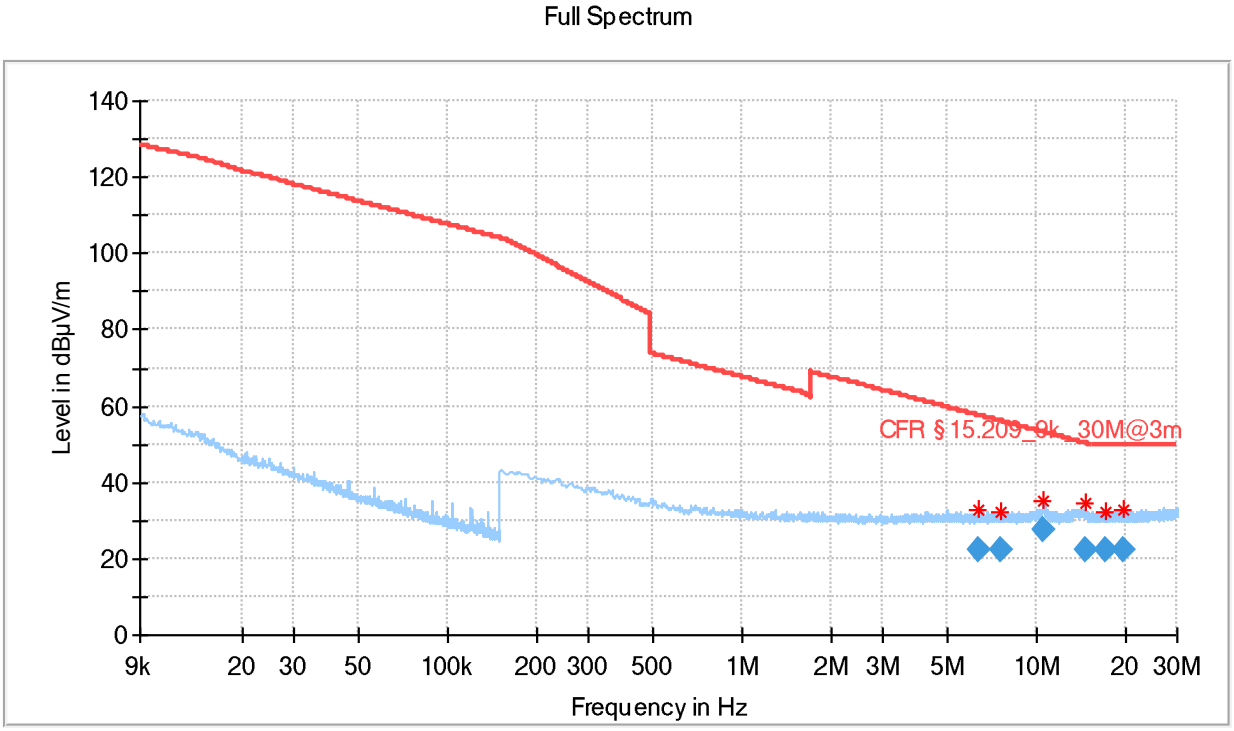
Plot 24: Mode 1, RSE 9 kHz – 30 MHz, mid channel, loop antenna



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Azimuth (deg)	Corr. (dB/m)
10.576500	27.82	53.10	25.28	15000.0	9.000	240.0	20.5
12.696000	21.96	51.51	29.55	15000.0	9.000	180.0	20.5
13.731000	23.51	50.83	27.33	15000.0	9.000	0.0	20.5
16.797750	21.89	49.54	27.65	15000.0	9.000	120.0	20.5
26.738250	22.28	49.54	27.26	15000.0	9.000	60.0	20.7
27.822750	22.46	49.54	27.08	15000.0	9.000	180.0	20.7

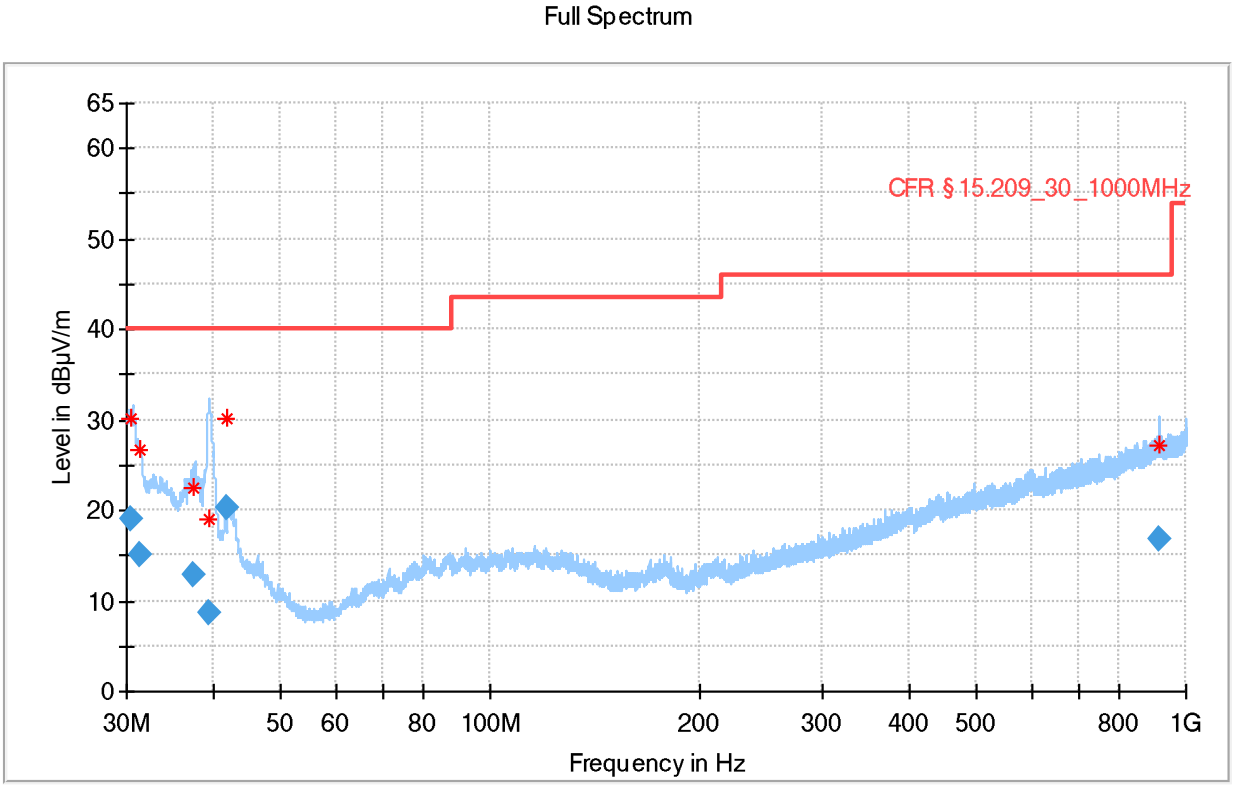
Plot 25: Mode 1, RSE 9 kHz – 30 MHz, high channel, loop antenna



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Azimuth (deg)	Corr. (dB/m)
6.346500	22.12	57.56	35.43	15000.0	9.000	120.0	20.4
7.613250	22.01	55.97	33.96	15000.0	9.000	120.0	20.4
10.608000	27.45	53.08	25.63	15000.0	9.000	300.0	20.5
14.797500	22.35	50.18	27.83	15000.0	9.000	120.0	20.5
17.232000	21.97	49.54	27.57	15000.0	9.000	0.0	20.5
19.799250	22.01	49.54	27.53	15000.0	9.000	60.0	20.5

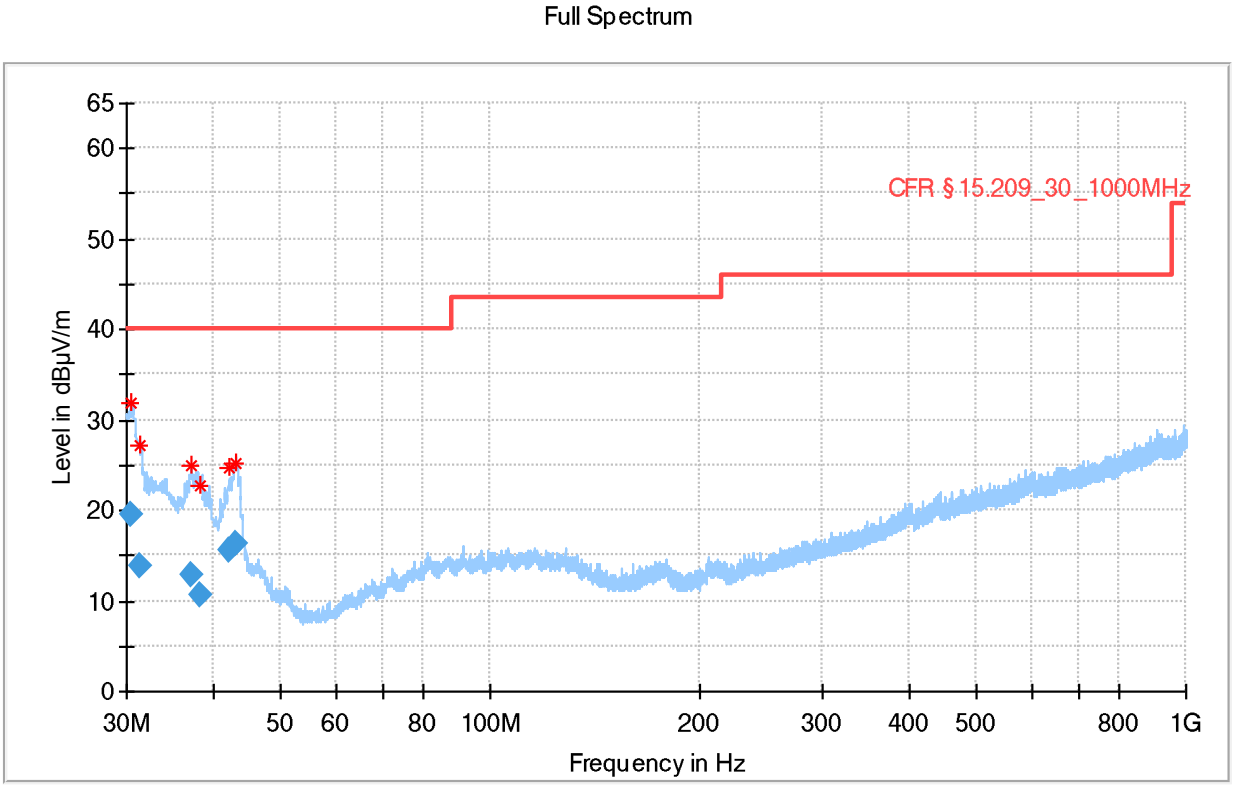
Plot 26: Mode 1, RSE 30 MHz – 1 GHz, low channel, horizontal / vertical polarisation



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.540000	19.02	40.00	20.98	15000.0	120.000	100.0	V	237.0	20.3
31.410000	15.16	40.00	24.84	15000.0	120.000	400.0	V	17.0	19.8
37.560000	12.97	40.00	27.03	15000.0	120.000	104.0	V	257.0	16.5
39.480000	8.71	40.00	31.29	15000.0	120.000	130.0	V	151.0	15.3
41.850000	20.28	40.00	19.72	15000.0	120.000	130.0	V	36.0	13.8
912.990000	16.85	46.00	29.15	15000.0	120.000	400.0	H	227.0	24.3

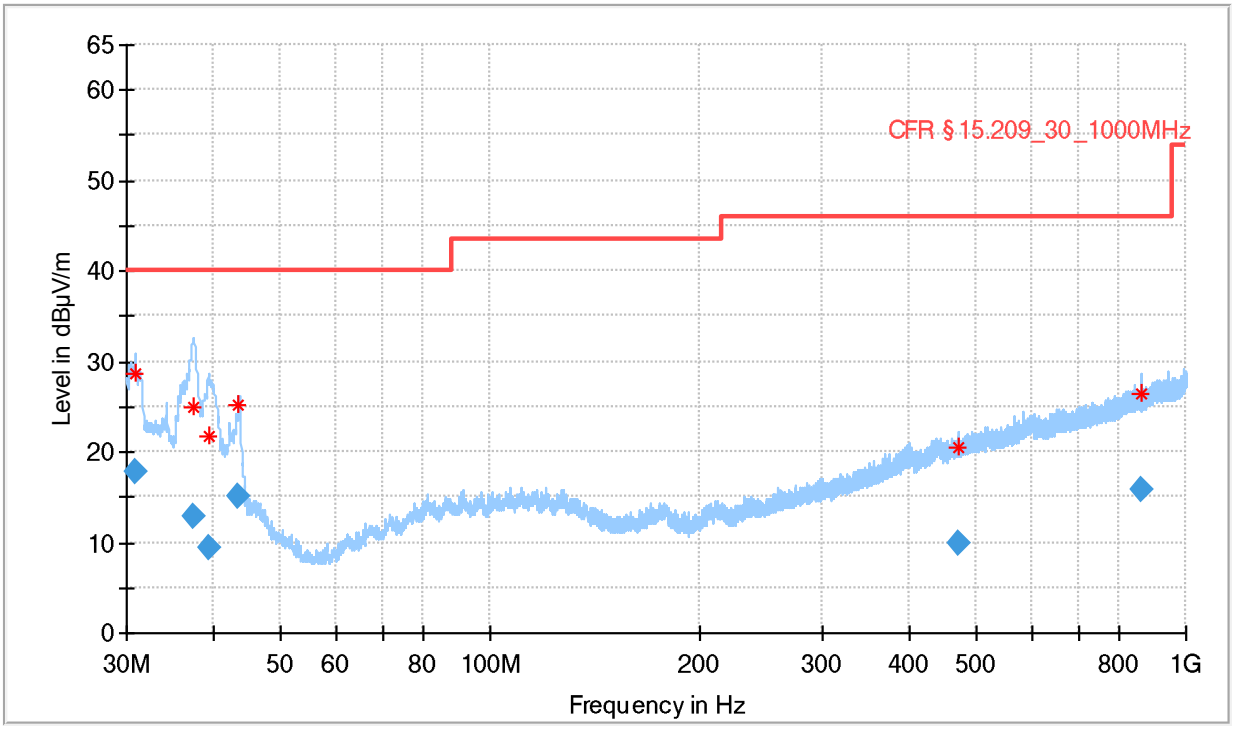
Plot 27: Mode 1, RSE 30 MHz – 1 GHz, mid channel, horizontal / vertical polarisation



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.450000	19.55	40.00	20.45	15000.0	120.000	100.0	V	-29.0	20.3
31.410000	13.83	40.00	26.17	15000.0	120.000	374.0	V	17.0	19.8
37.200000	12.93	40.00	27.07	15000.0	120.000	104.0	V	-29.0	16.7
38.370000	10.71	40.00	29.29	15000.0	120.000	100.0	V	201.0	16.0
42.270000	15.62	40.00	24.38	15000.0	120.000	121.0	V	237.0	13.5
43.110000	16.32	40.00	23.68	15000.0	120.000	100.0	V	241.0	13.0

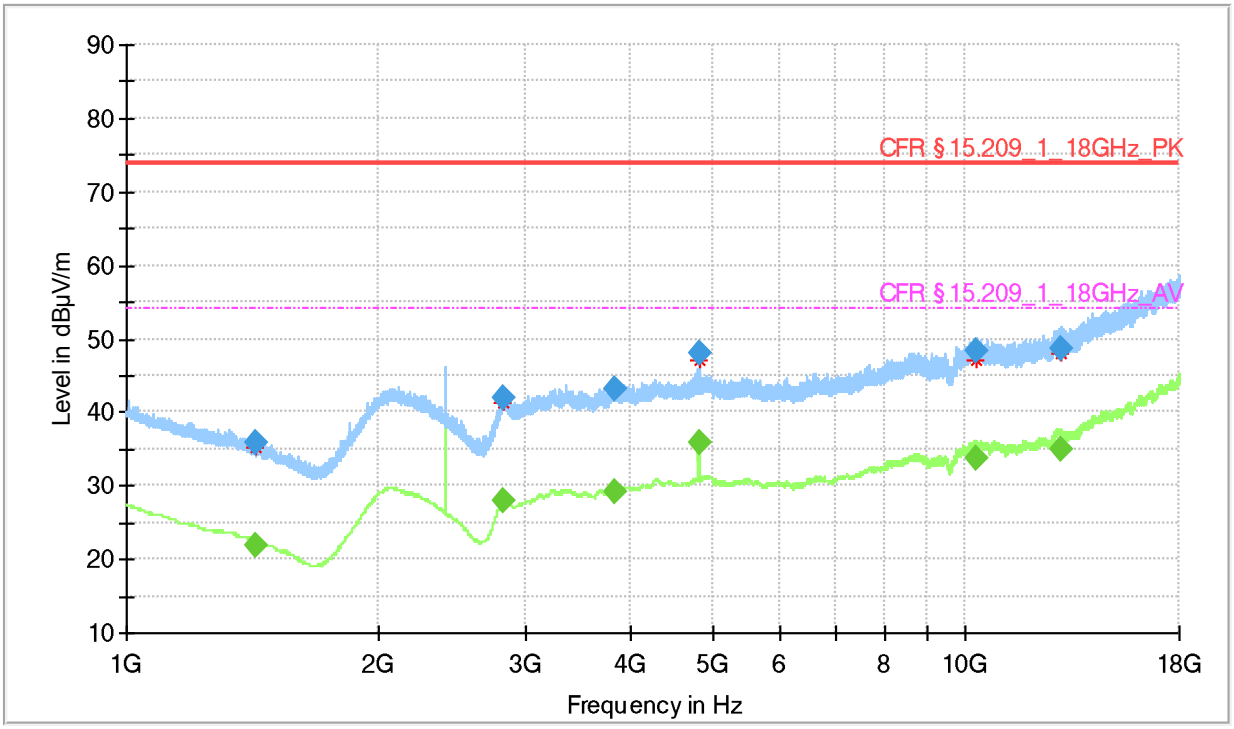
Plot 28: Mode 1, RSE 30 MHz – 1 GHz, high channel, horizontal / vertical polarisation



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.840000	17.91	40.00	22.09	15000.0	120.000	400.0	V	17.0	20.2
37.380000	12.74	40.00	27.26	15000.0	120.000	100.0	V	201.0	16.6
39.330000	9.45	40.00	30.55	15000.0	120.000	104.0	V	216.0	15.4
43.500000	15.19	40.00	24.81	15000.0	120.000	100.0	H	287.0	12.7
472.650000	9.91	46.00	36.09	15000.0	120.000	130.0	V	246.0	18.3
861.120000	15.84	46.00	30.16	15000.0	120.000	130.0	V	-19.0	23.5

Plot 29: Mode 1, RSE 1 GHz – 18 GHz, low channel, horizontal / vertical polarisation

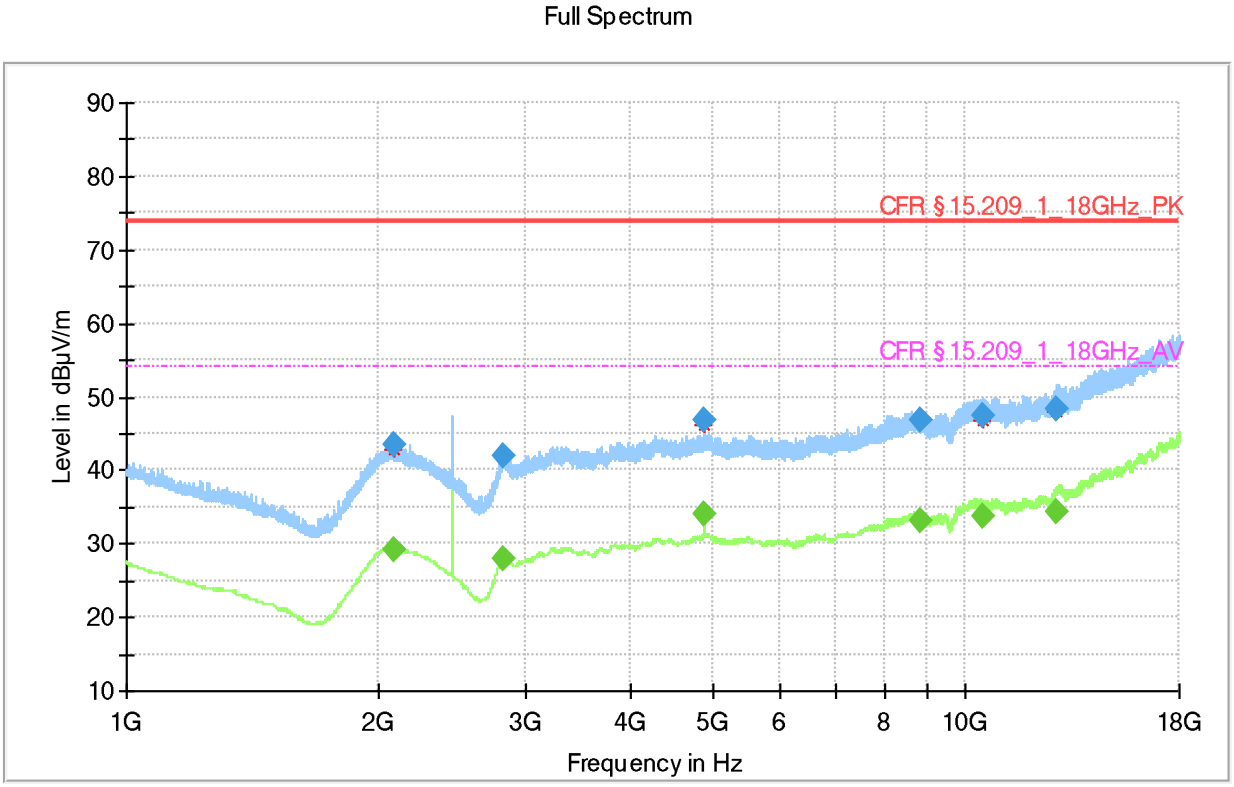


Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
1425.750000	35.86	---	74.00	38.14	15000.0	1000.000	V	272.0	-1.5
1425.750000	---	21.74	54.00	32.26	15000.0	1000.000	V	272.0	-1.5
2808.500000	41.94	---	74.00	32.06	15000.0	1000.000	H	108.0	4.1
2808.500000	---	27.96	54.00	26.04	15000.0	1000.000	H	108.0	4.1
3811.500000	---	29.12	54.00	24.88	15000.0	1000.000	V	358.0	8.4
3811.500000	43.06	---	74.00	30.94	15000.0	1000.000	V	358.0	8.4
4811.000000	---	35.90	54.00	18.10	15000.0	1000.000	V	251.0	10.4
4811.000000	47.91	---	74.00	26.09	15000.0	1000.000	V	251.0	10.4
10290.00000	---	33.74	54.00	20.26	15000.0	1000.000	H	211.0	16.9
10290.00000	48.45	---	74.00	25.55	15000.0	1000.000	H	211.0	16.9
12996.25000	---	34.85	54.00	19.15	15000.0	1000.000	V	221.0	19.3
12996.25000	48.78	---	74.00	25.22	15000.0	1000.000	V	221.0	19.3

Note: Carrier suppressed!

Plot 30: Mode 1, RSE 1 GHz – 18 GHz, mid channel, horizontal / vertical polarisation

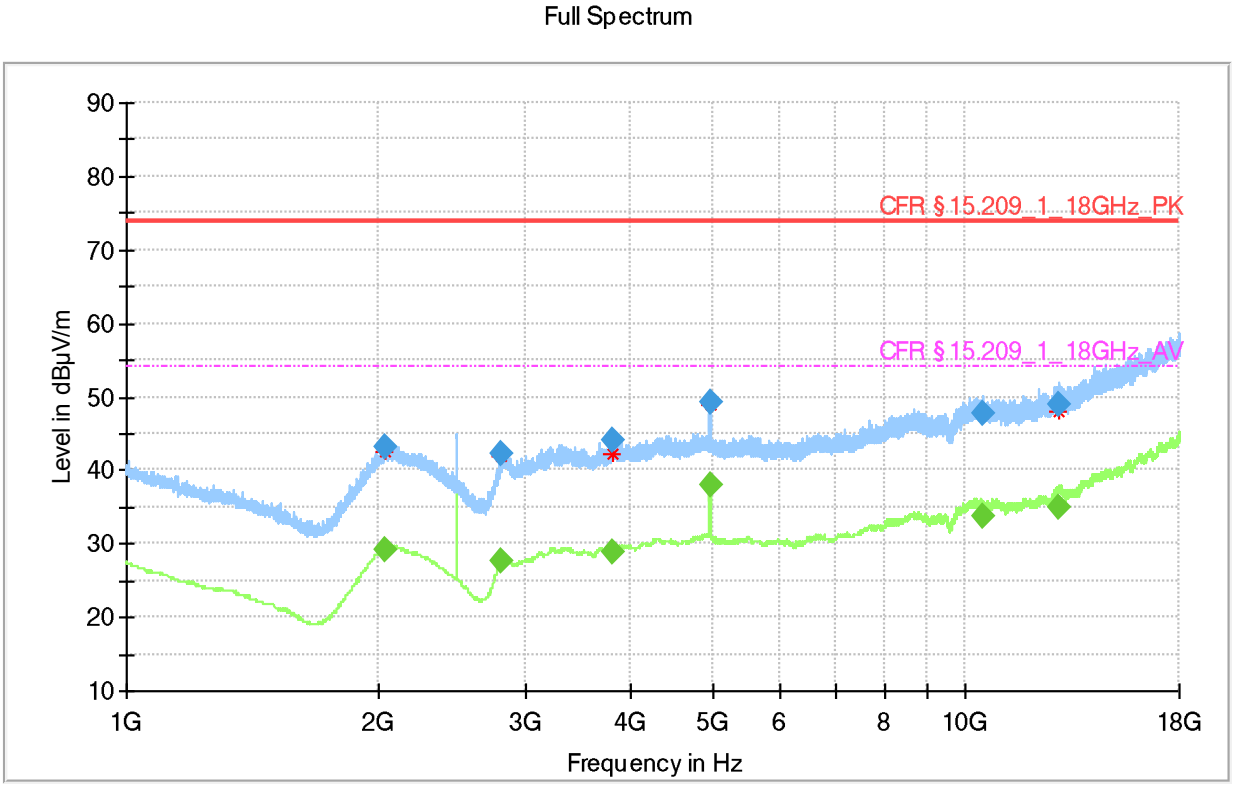


Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
2083.250000	43.38	---	74.00	30.62	15000.0	1000.000	V	273.0	2.3
2083.250000	---	29.25	54.00	24.75	15000.0	1000.000	V	273.0	2.3
2812.500000	---	27.97	54.00	26.03	15000.0	1000.000	V	335.0	4.1
2812.500000	42.07	---	74.00	31.93	15000.0	1000.000	V	335.0	4.1
4879.000000	---	34.14	54.00	19.86	15000.0	1000.000	V	275.0	10.6
4879.000000	46.90	---	74.00	27.10	15000.0	1000.000	V	275.0	10.6
8838.250000	---	33.26	54.00	20.74	15000.0	1000.000	V	47.0	15.6
8838.250000	46.78	---	74.00	27.22	15000.0	1000.000	V	47.0	15.6
10496.75000	---	33.73	54.00	20.27	15000.0	1000.000	H	124.0	17.0
10496.75000	47.40	---	74.00	26.60	15000.0	1000.000	H	124.0	17.0
12819.75000	48.25	---	74.00	25.75	15000.0	1000.000	V	235.0	19.1
12819.75000	---	34.34	54.00	19.66	15000.0	1000.000	V	235.0	19.1

Note: Carrier suppressed!

Plot 31: Mode 1, RSE 1 GHz – 18 GHz, high channel, horizontal / vertical polarisation

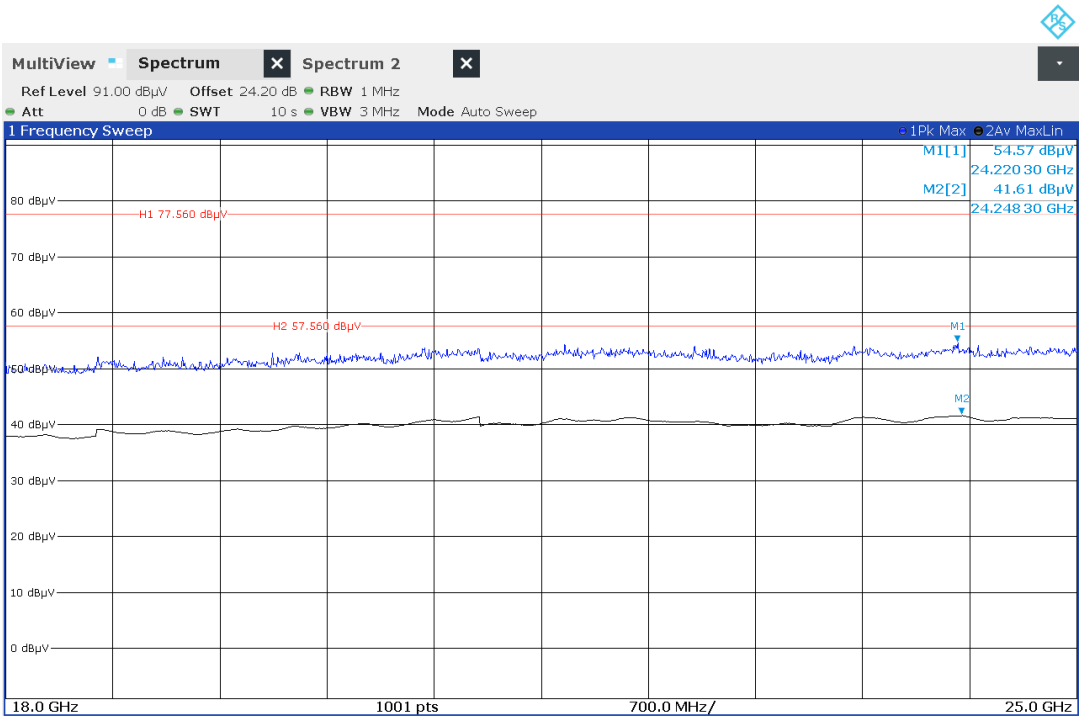


Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
2030.500000	43.28	---	74.00	30.72	15000.0	1000.000	V	328.0	2.5
2030.500000	---	29.03	54.00	24.97	15000.0	1000.000	V	328.0	2.5
2799.500000	42.19	---	74.00	31.81	15000.0	1000.000	H	167.0	4.0
2799.500000	---	27.69	54.00	26.31	15000.0	1000.000	H	167.0	4.0
3793.750000	---	28.89	54.00	25.11	15000.0	1000.000	H	36.0	8.3
3793.750000	43.94	---	74.00	30.06	15000.0	1000.000	H	36.0	8.3
4961.000000	49.10	---	74.00	24.90	15000.0	1000.000	V	238.0	10.8
4961.000000	---	38.03	54.00	15.97	15000.0	1000.000	V	238.0	10.8
10478.50000	47.76	---	74.00	26.24	15000.0	1000.000	H	307.0	17.0
10478.50000	---	33.80	54.00	20.20	15000.0	1000.000	H	307.0	17.0
12958.00000	---	34.88	54.00	19.12	15000.0	1000.000	H	59.0	19.2
12958.00000	48.99	---	74.00	25.01	15000.0	1000.000	H	59.0	19.2

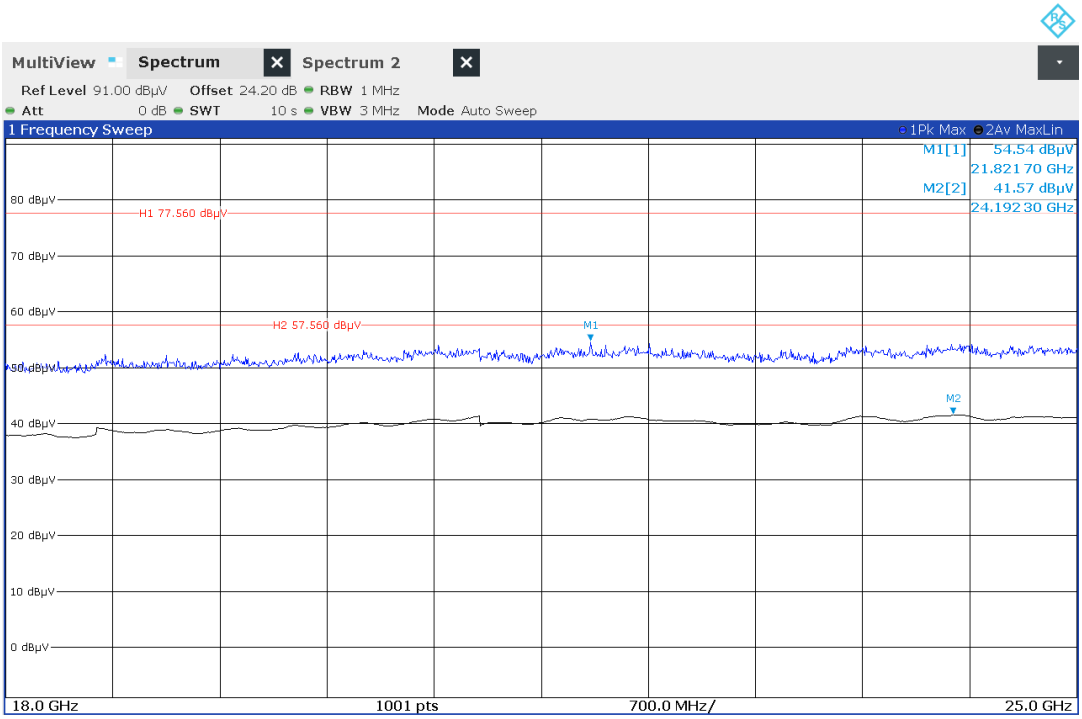
Note: Carrier suppressed!

Plot 32: Mode 1, RSE 18 GHz – 25 GHz, low channel, horizontal / vertical polarisation



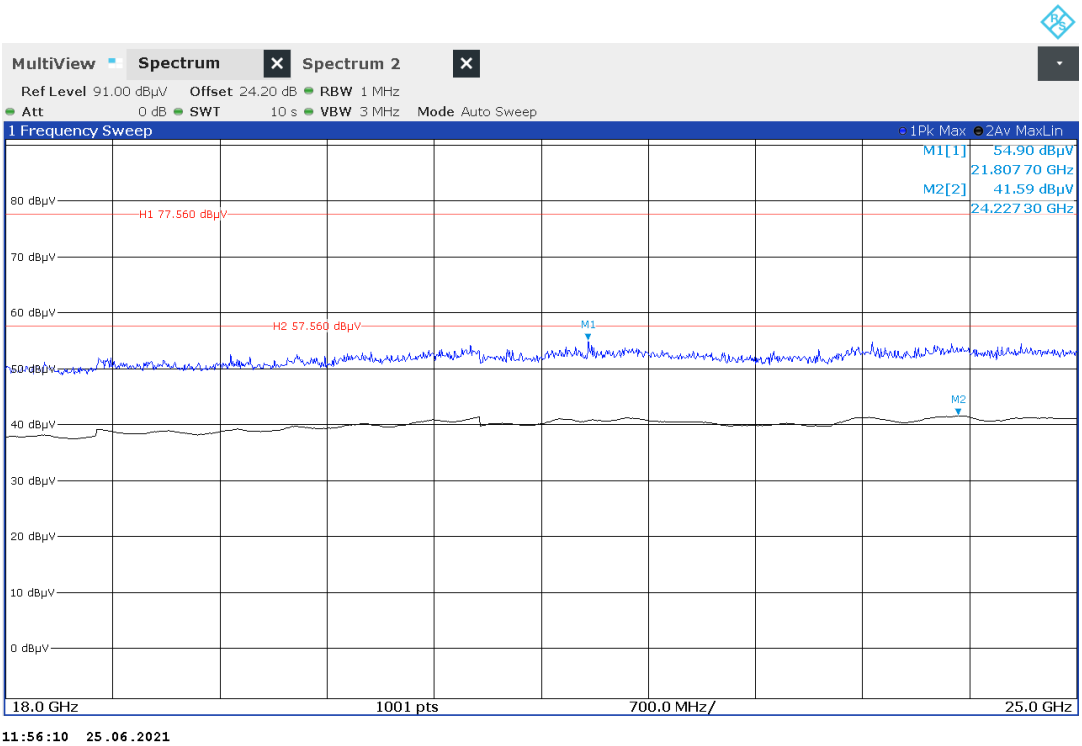
11:53:10 25.06.2021

Plot 33: Mode 1, RSE 18 GHz – 25 GHz, mid channel, horizontal / vertical polarisation



11:54:46 25.06.2021

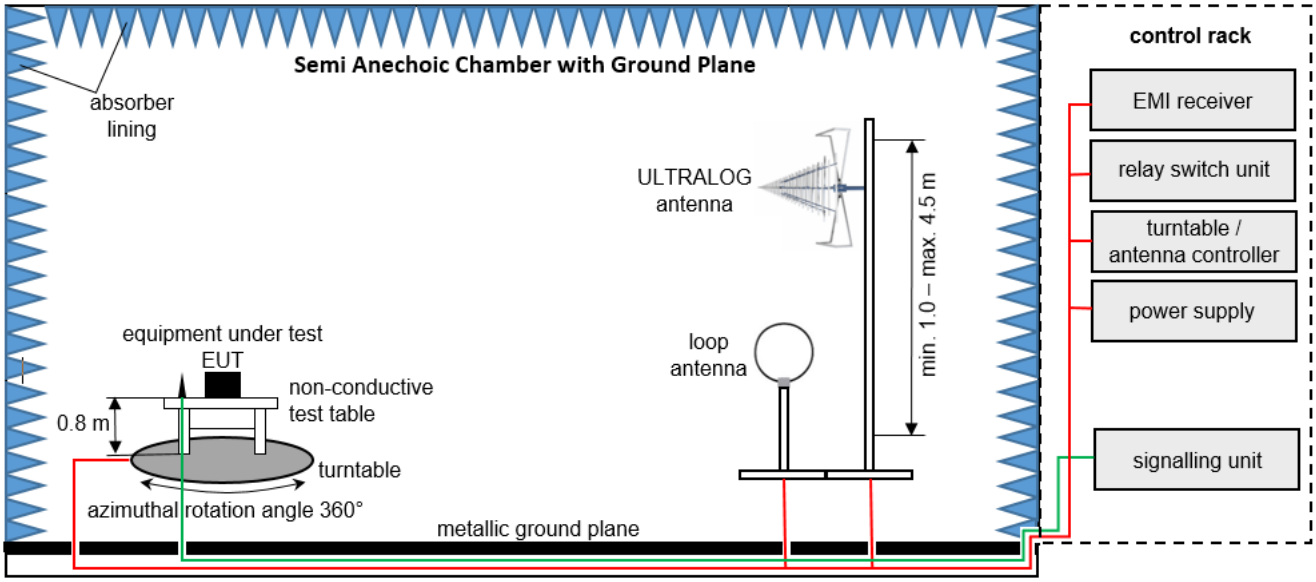
Plot 34: Mode 1, RSE 18 GHz – 25 GHz, high channel, horizontal / vertical polarisation



8 TEST SETUP DESCRIPTION

8.1 Semi Anechoic Chamber with Ground Plane

Radiated measurements are performed in vertical and horizontal plane in the frequency range 30 MHz to 1 GHz in a Semi Anechoic Chamber with a metallic ground plane. The EUT is positioned on a non-conductive test table with a height of 0.80 m above the metallic ground plane that covers the whole chamber. The receiving antennas conform to specification 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 4.5 m in order to search for maximum field strength emitted from the 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 a spectrum analyzer where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



Measurement distance: loop antenna 3 m, ULTRALOG antenna 3 m
EMC32 software version: 11.10.00

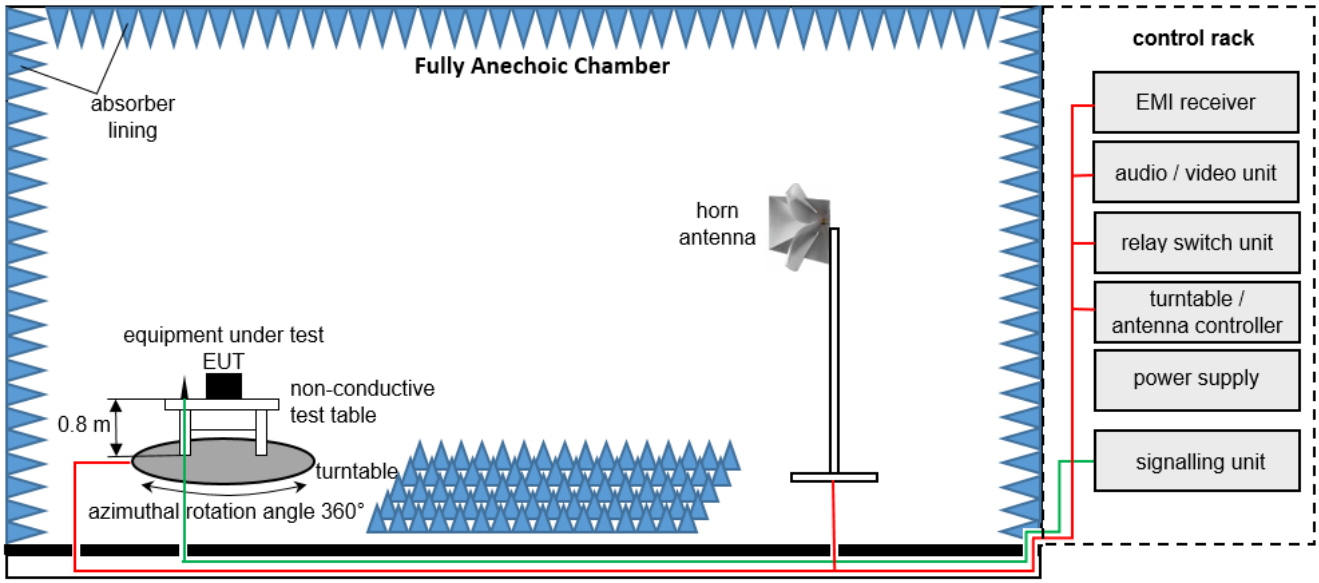
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	INV. No.	Last / Next Calibration
1	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PSI 9080-40 T	2000230001	LAB000313	–
2	Test table	innco systems GmbH	PT1208-080-RH	-	LAB000306	–
3	Power Supply	Chroma	61604	616040005416	LAB000285	–
4	Positioner	maturo GmbH	TD 1.5-10KG		LAB000258	–
5	Compressed Air	Implotex	1-850-30	-	LAB000256	–
6	EMI Test Receiver	Rohde & Schwarz	ESW26	101481	LAB000236	2020-06-03 → 2021-06-03
7	Semi-Anechoic Chamber (SAC)	Albatross Projects GmbH	SAC 5 (Babylon 5)	20168.PRB	LAB000235	2020-08-24 → 2021-08-24
8	Measurement Software	Rohde & Schwarz	EMC32 V11.00.10		LAB000226	–
9	Turntable	maturo GmbH	TT2.0-2t	TT2.0-2t/921	LAB000225	–
10	Antenna Mast	maturo GmbH	CAM4.0-P	CAM4.0-P/316	LAB000224	–
11	Antenna Mast	maturo GmbH	BAM4.5-P	BAM4.5-P/272	LAB000223	–
12	Controller	maturo GmbH	FCU 3.0	10082	LAB000222	–
13	Power Supply	Elektro-Automatik GmbH & Co. KG	PS 2042-10 B	2878350292	LAB000191	–
14	Pre-Amplifier	Schwarzbeck Mess-Elektronik OHG	BBV 9718 C	84	LAB000169	–
15	Open Switch and Control Platform	Rohde & Schwarz	OSP200 Base Unit 2HU	101748	LAB000149	2020-07-07 → 2021-07-07
16	Antenna	Rohde & Schwarz	HL562E	102001	LAB000123	2020-07-05 → 2023-07-05
17	Antenna	Rohde & Schwarz	HFH2-Z2E - Active Loop Antenna	100954	LAB000108	2020-03-25 → 2023-03-25
18	EMI Test Receiver	Rohde & Schwarz	ESW26	101512	LAB000363	2021-02-05 → 2022-02-05

8.2 Fully Anechoic Chamber



Measurement distance: horn antenna 3 meter
EMC32 software version: 11.10.00

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)

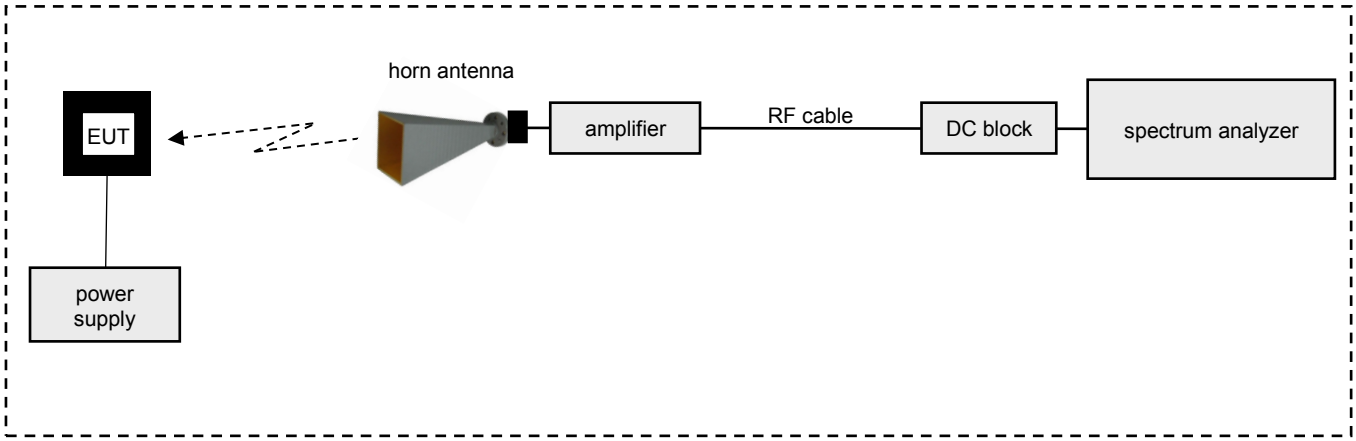
OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

Example calculation:
OP [dBm] = -65.0 [dBm] + 50 [dB] - 20 [dBi] + 5 [dB] = -30 [dBm] (1 µW)

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	INV. No.	Last / Next Calibration
1	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PSI 9080-40 T	2000230001	LAB000313	–
2	Test table	innco systems GmbH	PT1208-080-RH	-	LAB000306	–
3	Power Supply	Chroma	61604	616040005416	LAB000285	–
4	Positioner	maturo GmbH	TD 1.5-10KG		LAB000258	–
5	Compressed Air	Implotex	1-850-30	-	LAB000256	–
6	EMI Test Receiver	Rohde & Schwarz	ESW26	101517	LAB000363	2021-02-05 → 2022-02-05
7	Semi-Anechoic Chamber (SAC)	Albatross Projects GmbH	SAC 5 (Babylon 5)	20168.PRB	LAB000235	2020-08-24 → 2021-08-24
8	Measurement Software	Rohde & Schwarz	EMC32 V11.00.10		LAB000226	–
9	Turntable	maturo GmbH	TT2.0-2t	TT2.0-2t/921	LAB000225	–
10	Antenna Mast	maturo GmbH	BAM4.5-P	BAM4.5-P/272	LAB000223	–
11	Controller	maturo GmbH	FCU 3.0	10082	LAB000222	–
12	Power Supply	Elektro-Automatik GmbH & Co. KG	PS 2042-10 B	2878350292	LAB000191	–
13	Pre-Amplifier	Schwarzbeck Mess-Elektronik OHG	BBV 9718 C	84	LAB000169	–
14	Open Switch and Control Platform	Rohde & Schwarz	OSP200 Base Unit 2HU	101748	LAB000149	2020-07-07 → 2021-07-07
15	Antenna	Rohde & Schwarz	HF907	102898	LAB000124	2020-04-23 → 2023-04-23
16	EMI Test Receiver	Rohde & Schwarz	ESW26	101512	LAB000363	2021-02-05 → 2022-02-05

8.3 Radiated measurements > 18 GHz

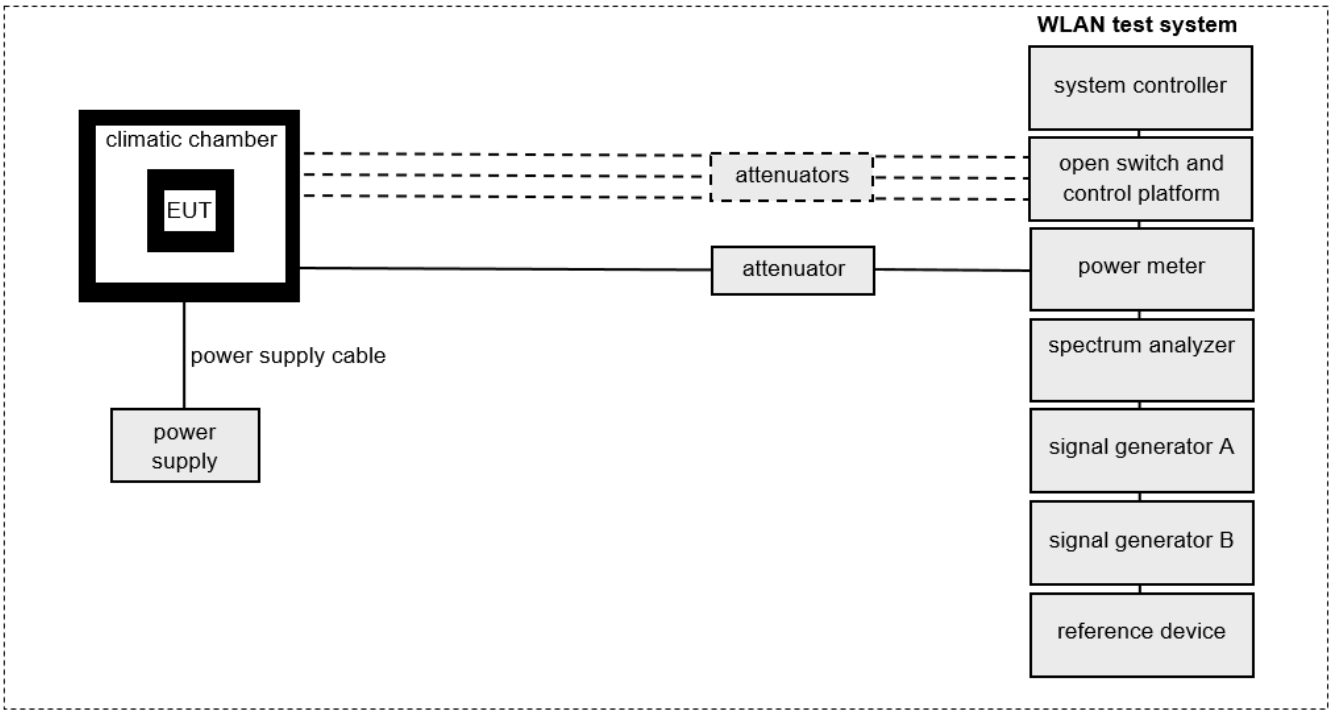


List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	INV. No.	Last / Next Calibration
1	Test table	innco systems GmbH	PT0707-RH light	-	LAB000303	–
2	WG-Coax-Adapter	Flann Microwave Ltd	20093-TF30 UBR220	273374	LAB000181	2020-07-01 → 2021-07-01
3	Coaxial Cable	Huber & Suhner	SF101/1.5m	503987/1	LAB000165	2020-06-05 → 2022-06-05
4	Antenna	Flann Microwave Ltd	20240-20	266403	LAB000128	2020-06-29 → 2021-06-29
5	Spectrum Analyser	Rohde & Schwarz	FSW50	101450	LAB000111	2020-05-05 → 2022-05-05

8.4 Conducted measurements WLAN test system R&S TS 8997

The EUT's RF signal is coupled out by the antenna connector which is supplied by the manufacturer. The losses for all signal paths are first checked within a calibration. The measurement readings on the signalling unit/spectrum analyzer are corrected by the specific test set-up loss. The attenuator, power divider, signalling unit and the spectrum analyzer are impedance matched on 50 Ohm.



EMC32/WMS32 software version: 11.00.00

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	INV. No.	Last Verification
1	TS8997-Rack	Rohde & Schwarz	TS8997-Rack	100829	LAB000322	–
2	Open Switch and Control Platform	Rohde & Schwarz	OSP-B157WX	101247	LAB000280	2021-01-11
3	Open Switch and Control Platform	Rohde & Schwarz	OSP-B157W8	100982	LAB000279	2021-01-11
4	Spectrum Analyser	Rohde & Schwarz	FSV40	101403	LAB000278	2021-01-11
5	Signal Generator	Rohde & Schwarz	SMBV100A	258240	LAB000277	2021-01-11
6	Signal Generator	Rohde & Schwarz	SMB100A-20	178175	LAB000276	2021-01-11
7	Radio Communication Tester	Rohde & Schwarz	CMW270	101479	LAB000275	2021-01-11
8	Controller	Hewlett Packard	ATS-Z230	101379	LAB000274	–
9	Power Supply	EA	PS 2042-10 B	2878350263	LAB000190	–

9 MEASUREMENT UNCERTAINTIES

Radio frequency	≤ ± 1 x 10^{-7}
RF power, conducted	≤ ± 0.75 dB
Power spectral density	≤ ± 3 dB
Maximum frequency deviation	≤ ± 5 %
Deviation limitation Duty Cycle, Tx-sequence, Tx-gap	≤ ± 5 %
Occupied channel bandwidth	≤ ± 5 %
Conducted spurious emission of transmitter	≤ ± 4 dB
Conducted emission of receivers	≤ ± 4 dB
Radiated emission of transmitter	≤ ± 6 dB
Radiated emission of receiver	≤ ± 6 dB
Temperature	≤ ± 2.5 °C
Humidity	≤ ± 10 %

The indicated expanded measurement uncertainty corresponds to the standard measurement uncertainty for the measurement results multiplied by the coverage factor k = 2. It was determined in accordance with EA-4/02 M:2013. The true value is located in the corresponding interval with a probability of 95 %.

Annex A EUT Photographs, external

Photo No. 1:

Photo No. 2:

Photo No. 3:

Photo No. 4:

Photo No. 5:

Photo No. 6:

Photo No. 7:

Photo No. 8:

Annex B EUT Photographs, internal

Photo No. 9:

Photo No. 10:

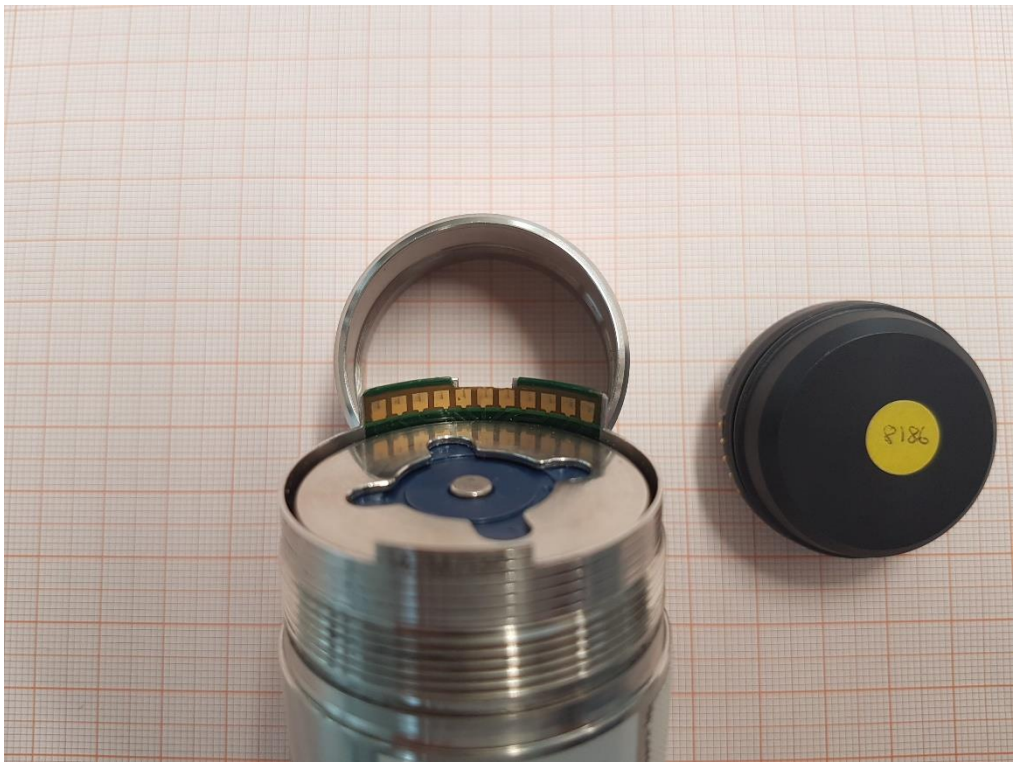


Photo No. 11:

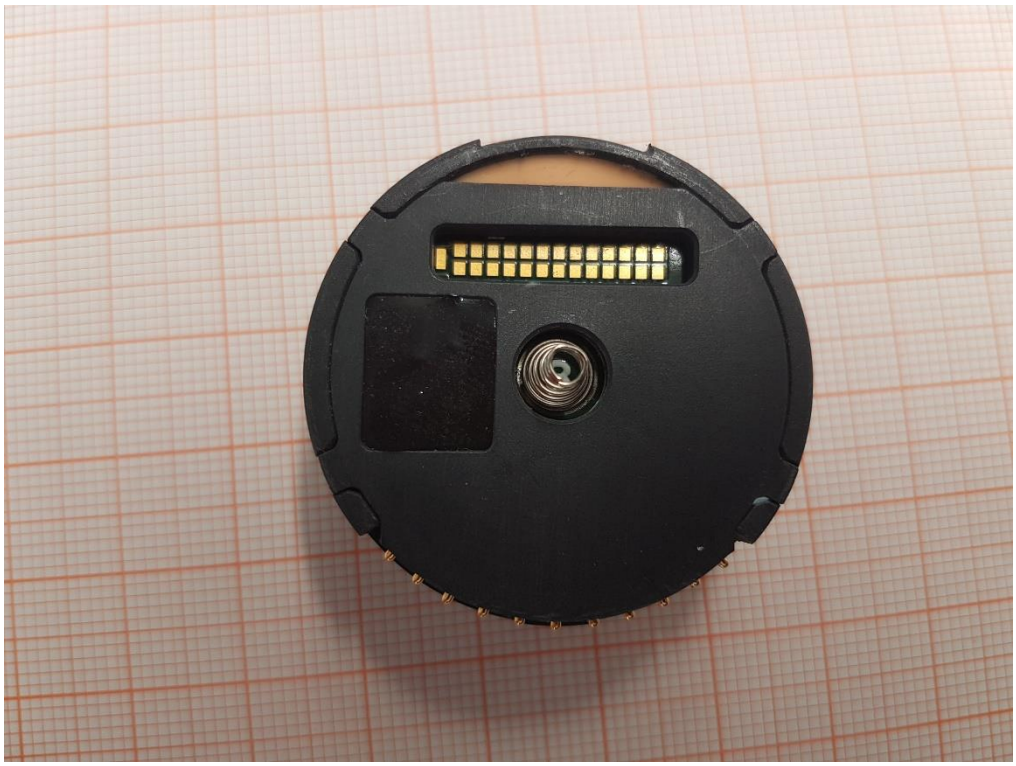


Photo No. 12:

Photo No. 13:

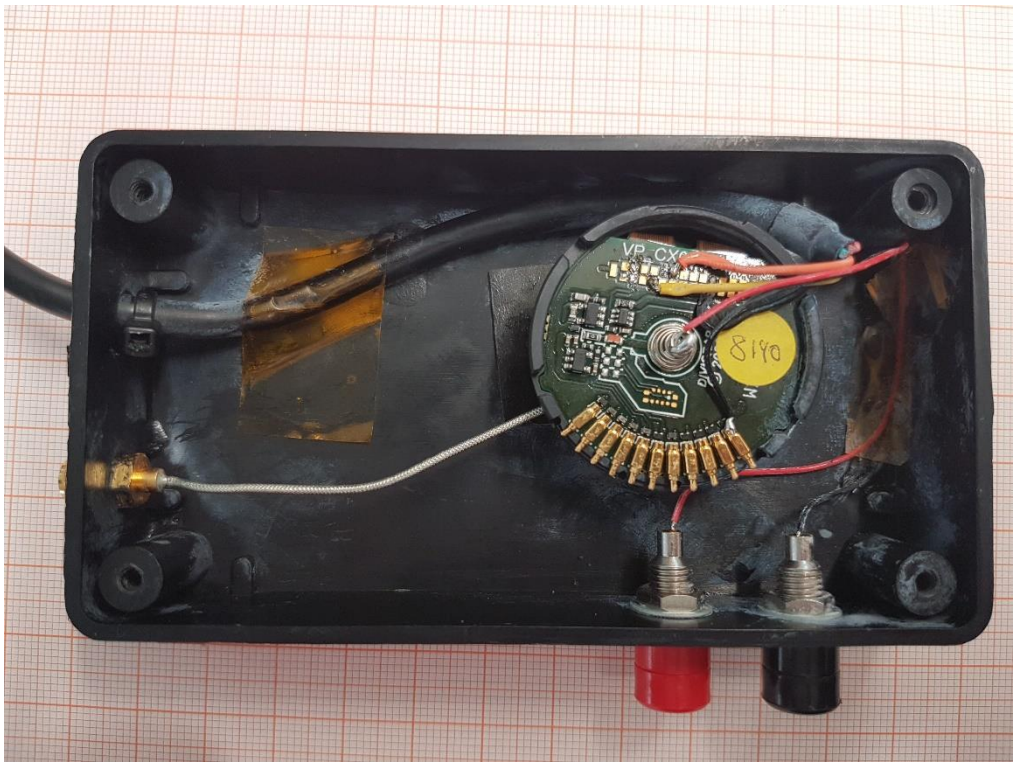
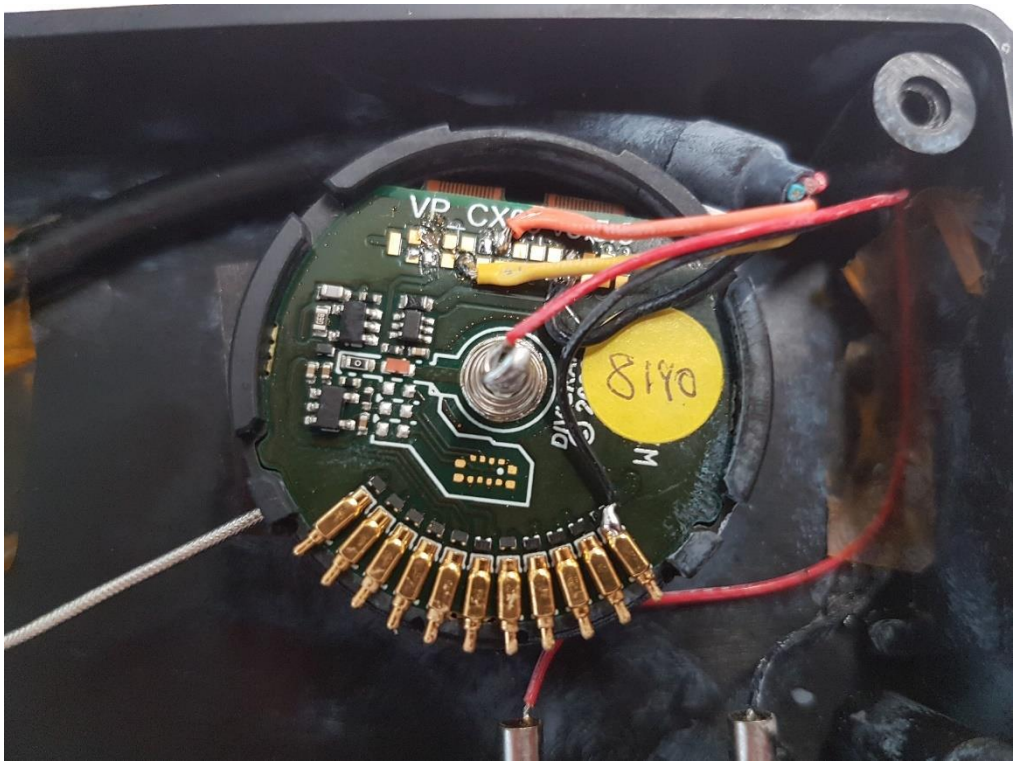
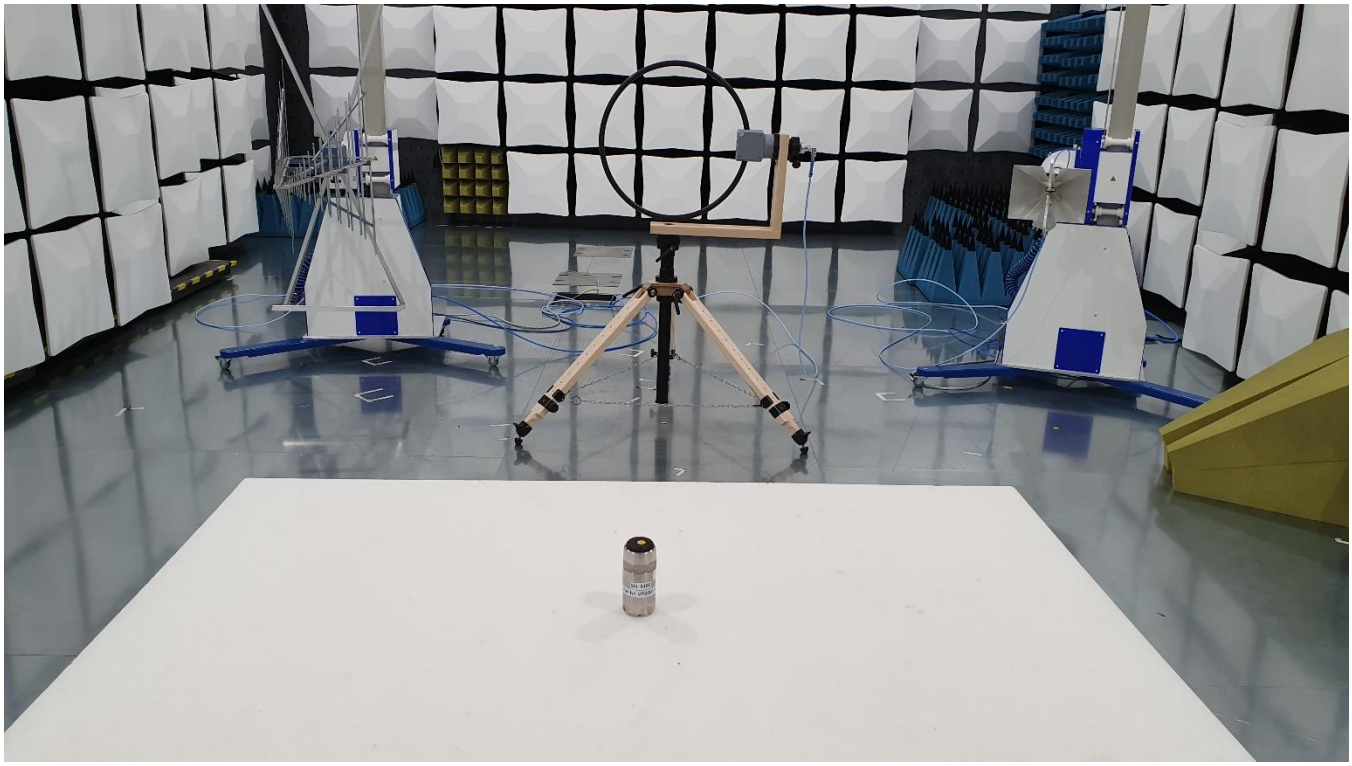


Photo No. 14:



Annex C Test Setup Photographs

Photo No. 15:



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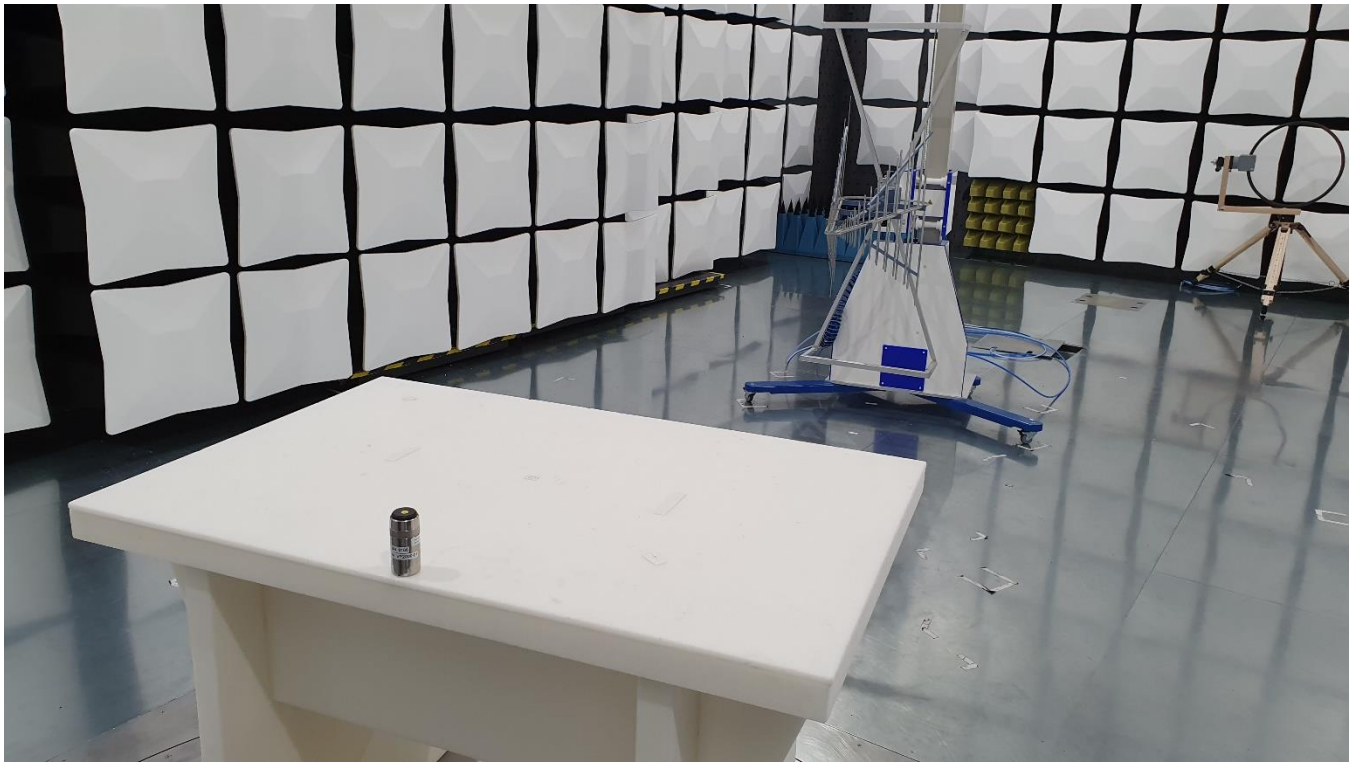

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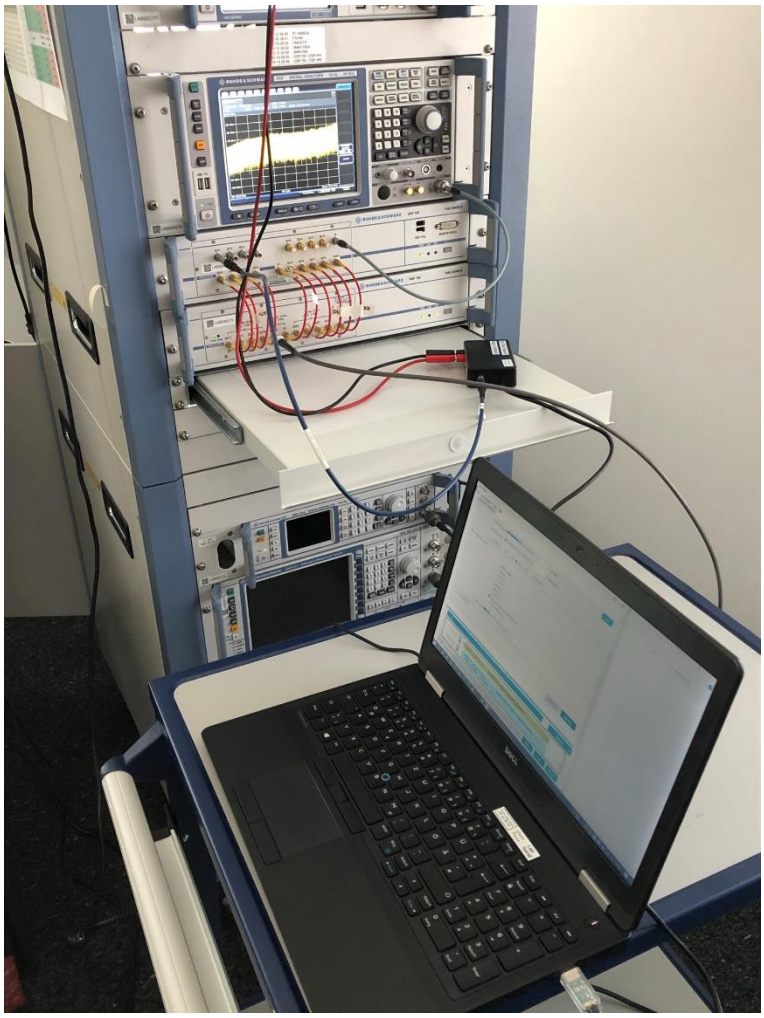
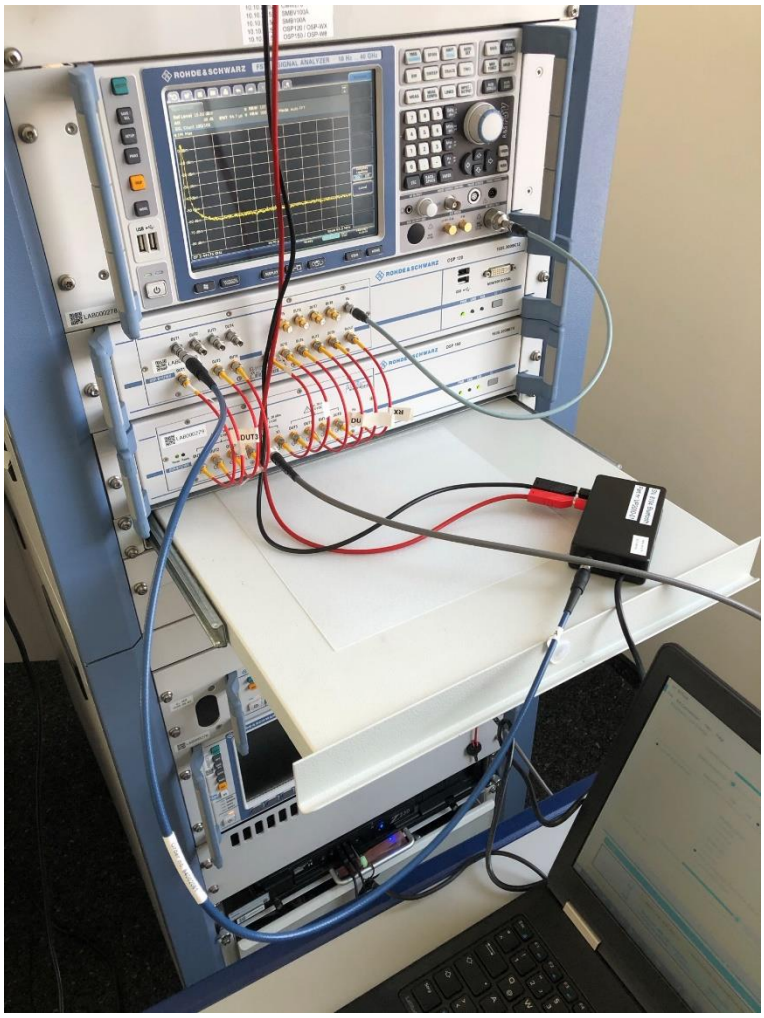


Photo No. 18:



End of Test Report