PHOENIX TESTLAB

Königswinkel 10
32825 Blomberg, Germany
Phone: +49 (0) 52 35 / 95 00-0
Fax: +49 (0) 52 35 / 95 00-10
office@phoenix-testlab.de
www.phoenix-testlab.de

Test Report

Report Number:

F191168E2

Equipment under Test (EUT):

Track&Trace - Marker

Applicant:

TRUMPF Werkzeugmaschinen GmbH + Co. KG

Manufacturer:

TRUMPF Werkzeugmaschinen GmbH + Co. KG

ilac-MRA DAkkS Deutsche Akkreditierungsstelle
D-PL-17186-01-01
D-PL-17186-01-02
D-PL-17186-01-03

References

[1] **ANSI C63.10-2013**, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

[2] **FCC CFR 47 Part 15**, Radio Frequency Devices

[3] **393764 D01 UWB FAQ v02**, ULTRA-WIDEBAND (UWB) DEVICES FREQUENTLY ASKED QUESTIONS

TEST RESULT

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test.
The complete test results are presented in the following.

Tested and written by:	Thomas KÜHN		07.07.2020
	Name	Signature	Date
Reviewed and approved by:	Bernd STEINER		07.07.2020
	Name	Signature	Date

This test report is only valid in its original form.

The test results herein refer only to the tested sample. PHOENIX TESTLAB GmbH is not responsible for any generalisations or conclusions drawn from these test results concerning further samples. Any modification of the tested samples is prohibited and leads to the invalidity of this test report. Each page necessarily contains the PHOENIX TESTLAB Logo and the TEST REPORT NUMBER.

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1 Identification

1.1 Applicant

Name:	TRUMPF Werkzeugmaschinen GmbH + Co. KG
Address:	Johann-Maus-Str. 2, 71254 Ditzingen
Country:	Germany
Name for contact purposes:	Mr. Sebastian Ochs
Phone:	+49 71 56 303 - 35 927
Fax:	+49 71 56 303 – 93 59 27
eMail Address:	sebastian.ochs@de.trumpf.com
Applicant represented during the test by the following person:	---

1.2 Manufacturer

Name:	TRUMPF Werkzeugmaschinen GmbH + Co. KG
Address:	Johann-Maus-Str. 2, 71254 Ditzingen
Country:	Germany
Name for contact purposes:	Mr. Sebastian Ochs
Phone:	+49 71 56 303 - 35 927
Fax:	+49 71 56 303 – 93 59 27
eMail Address:	sebastian.ochs@de.trumpf.com
Manufacturer represented during the test by the following person:	---

1.3 Test laboratory

The tests were carried out at:

PHOENIX TESTLAB GmbH
Königswinkel 10
32825 Blomberg
Germany

Accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-05 and D-PL-17186-01-06, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623.

1.4 EUT (Equipment Under Test)

Test object: *	Track&Trace - Marker for indoor localization
Model name: *	Track&Trace - Marker Mat. No. 2564360
Serial number: *	204579377
FCC ID: *	2AVYV-2564360-01
PCB identifier: *	1901154A001032B8
Hardware version: *	Rev D
Software version: *	2.17.9
Lowest / highest internal frequency: *	32.768 kHz / 4500 MHz

*: Declared by the applicant.

Note: PHOENIX TESTLAB GmbH does not take samples. The samples used for tests are provided exclusively by the applicant.

1.5 Technical data of equipment

Channel 1	f_C = 3.575 GHz, 500 MHz bandwidth
Channel 4	f_C = 4.000 GHz, 500 MHz bandwidth
Channel 3	f_C = 4.500 GHz, 500 MHz bandwidth
Channel 4	f_C = 4.000 GHz, 1000 MHz bandwidth

Rated rf-output power: *	-41.3 dBm (e.i.r.p.)					
Antenna type: *	Internal PCB antenna only					
Antenna connector: *	None					
Supply voltage EUT: *	U_{nom}=	V_{DC}	U_{min}=	V_{DC}	U_{max}=	V_{DC}
Temperature range: *	-10 °C to 39 °					
Ancillary used for test:	Samsung S9 mobile phone with the app nRF Connect V4.24.1, wireless charger.					

* declared by the applicant.

Identification	Connector		Length *
	EUT	Ancillary	
-	No lines connectable to the EUT	-	-
-		-	-

*: Length during the test if not otherwise specified.

1.6 Dates

Date of receipt of test sample:	07.05.2020
Start of test:	17.06.2020
End of test:	29.06.2020

2 Operational states

The EUT is a mobile UWB transceiver device, which is intended to be used as indoor locating device.

All measurements were carried out with an unmodified test sample mounted with a test software.

The UWB operation mode could be selected via a Bluetooth connection to a mobile phone with the app nRF Connect V4.24.1. After the operation mode is selected, the Bluetooth operation of the EUT was switched off with placing it on a charging station. Placing the device on the charger again will switch on the Bluetooth operation of the EUT.

During all measurements the EUT was supplied by a fully charged internal battery, which could be charged with wireless power transfer.

Because the EUT has no connector, all measurements were carried out radiated.

The transmit power level could be adjusted with the test software on the mobile phone. The following power levels were used to reach the documented results:

Channel No.	Power setting
1	0
2	-1
3	-2
4	0

3 Additional information

It was agreed between the applicant and the laboratory to test the EUT as handheld device according to FCC 47 CFR Part 15.519. After testing was completed it was clarified by the FCC, that the device can be certified as indoor device according to FCC 47 CFR Part 15.517. The limits in the final test results were changed accordingly but the limits shown in the plots at the more stringent limits of the FCC 47 CFR Part 15.519.
The EUT was not labeled as required by FCC.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	Status	Refer page
10 dB bandwidth	3100 - 10600	15.517 (b)	Passed	7 et seq.
Peak level of transmission	3100 - 10600	15.517 (e)	Passed	11 et seq.
Radiated emissions (transmitter)	0.009 - 40000	15.517 (c) 15.517 (d) 15.205 (a) 15.209 (a)	Passed	14 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	Not applicable *1	-
Antenna requirement	-	15.517 (2)	Passed *2	-

*1: Battery supplied device without any connector, the battery will be charged wireless.
*2: As declared by the applicant, the EUT is intended to be used with the internal PCB antenna only. No external antennas should be connected to the EUT. The internal UFL-connector is intended for test purposes only. Therefore, the antenna requirement could be regarded as fulfilled.

5 Test results

5.1 10 dB bandwidth

5.1.1 Method of measurement (10 dB bandwidth)

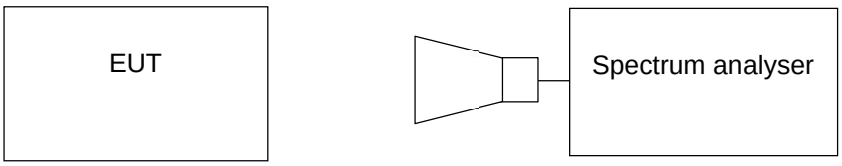
The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT has to be switched on and the hopping function has to be disabled, the transmitter shall work with its maximum data rate.

The following spectrum analyser settings according to [1] shall be used:

- Span: App. 2 to 5 times the 10 dB bandwidth.
- Resolution bandwidth: 1 MHz.
- Video bandwidth: ≥ the RBW.
- Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation.
- Sweep time: 1 ms / sweep point.
- Detector function: Peak.
- Trace mode: Max hold.

After trace stabilization the marker shall be set on the signal peak. The first display line has to be set on this value. The second display line has to be set 10 dB below the first line (or the peak marker). The frequency lines shall be set on the intersection points between the second display line and the measured curve.

Test set-up:

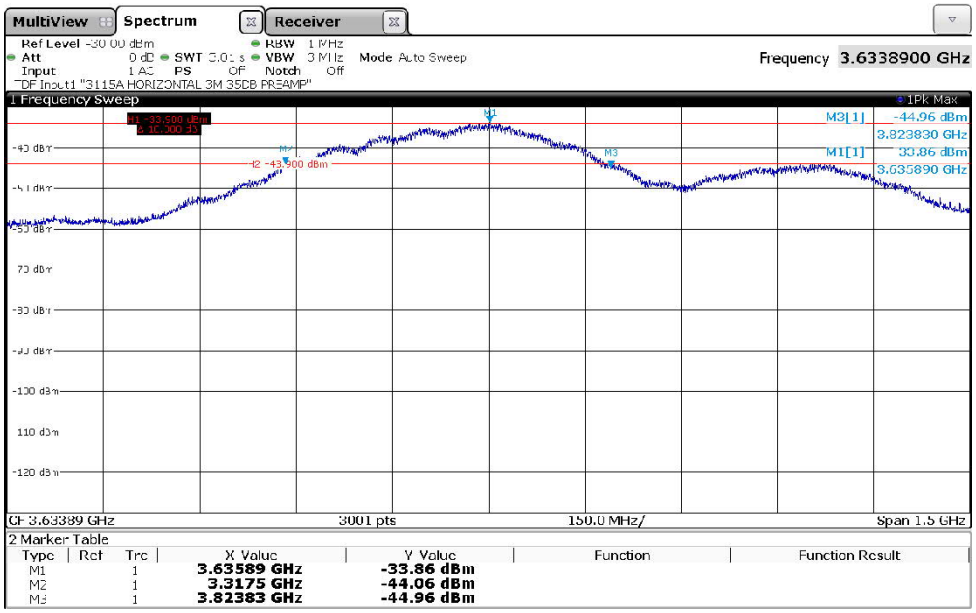


5.1.2 Test results (10 dB bandwidth)

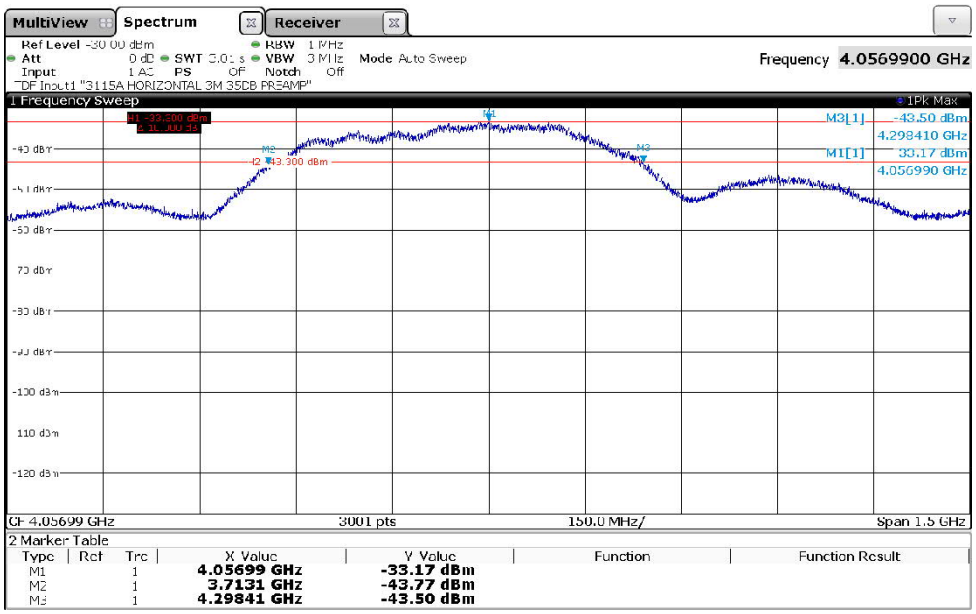
Ambient temperature	22 °C

Relative humidity	60 %

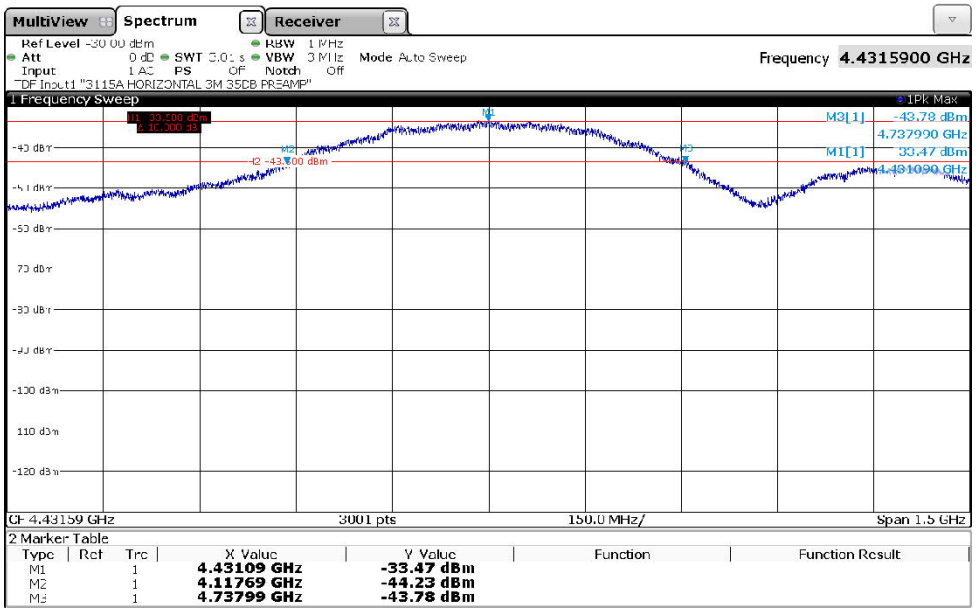
191168_1.png: 10 dB bandwidth on channel 1:



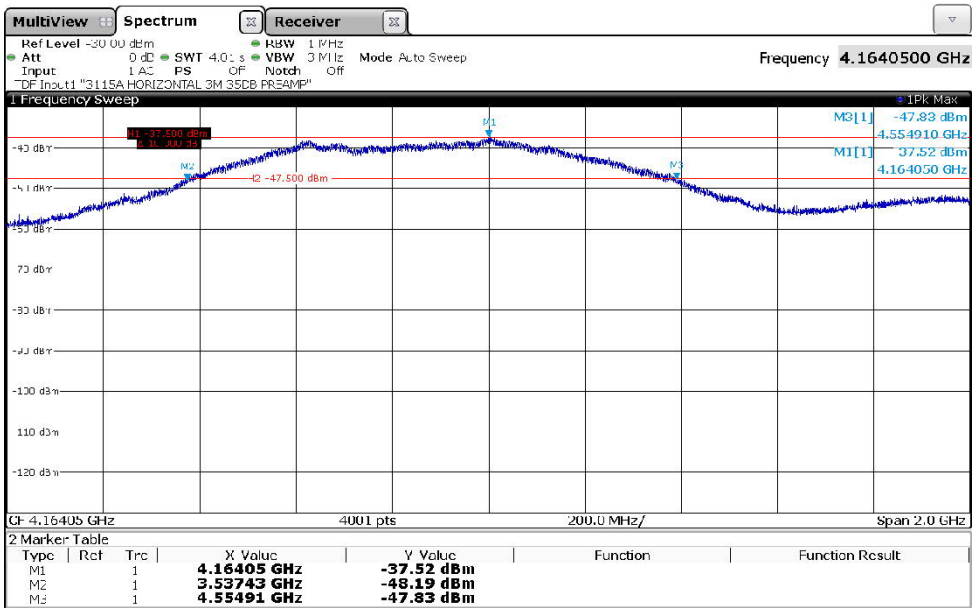
191168_3.png: 10 dB bandwidth on channel 2:



191168_5.png: 10 dB bandwidth on channel 3:



191168_7.png: 10 dB bandwidth on channel 4:



Channel number	Higher frequency f_H [MHz]	Lower frequency f_L [MHz]	10 dB bandwidth f_H-f_L [GHz]	Center frequency $(f_{H+}f_L)/2$ [MHz]	Fractional bandwidth
1	3823.830	3317.500	0.50633	3570.665	0.142
2	4298.410	3713.100	0.58531	4005.755	0.146
3	4737.990	4117.690	0.62030	4427.840	0.140
4	4554.910	3537.430	1.01748	4046.170	0.251
Measurement uncertainty			+0.66 dB / -0.72 dB		

Test: Passed

Test equipment used (refer clause 6):

11 – 13, 17, 19, 26

5.2 Peak level of transmission

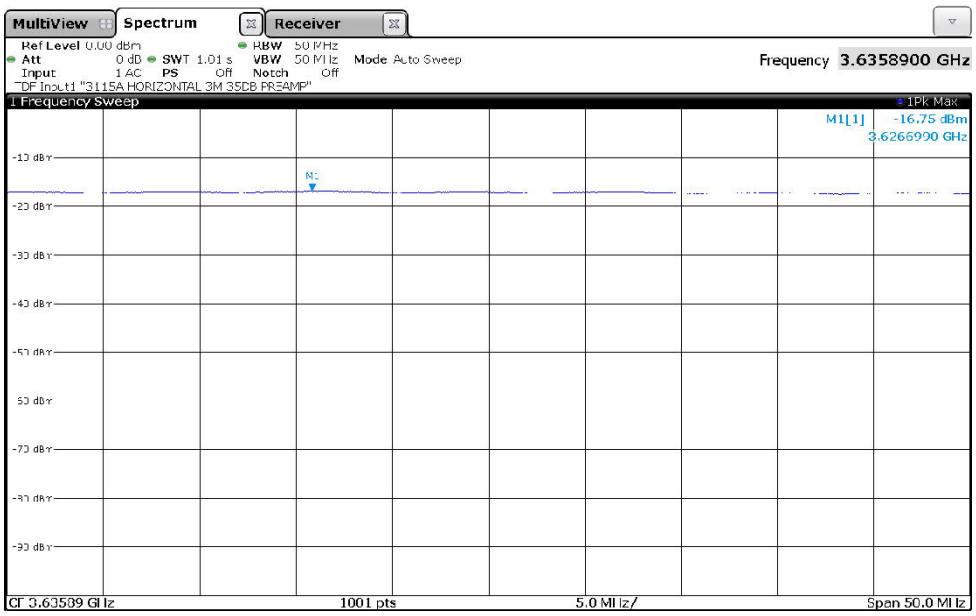
5.2.1 Method of measurement (peak level of transmission)

Because the EUT has no antenna connector, which presents the power delivered to the antenna, the peak value of the field strength was measured. The method of measurement is described under clause 5.3.1 (final measurement (1 GHz to 26.5 GHz)) of this test report with the exception that a peak detector and a resolution bandwidth of 50 MHz within a 50 MHz span centered at highest detected average emission level.

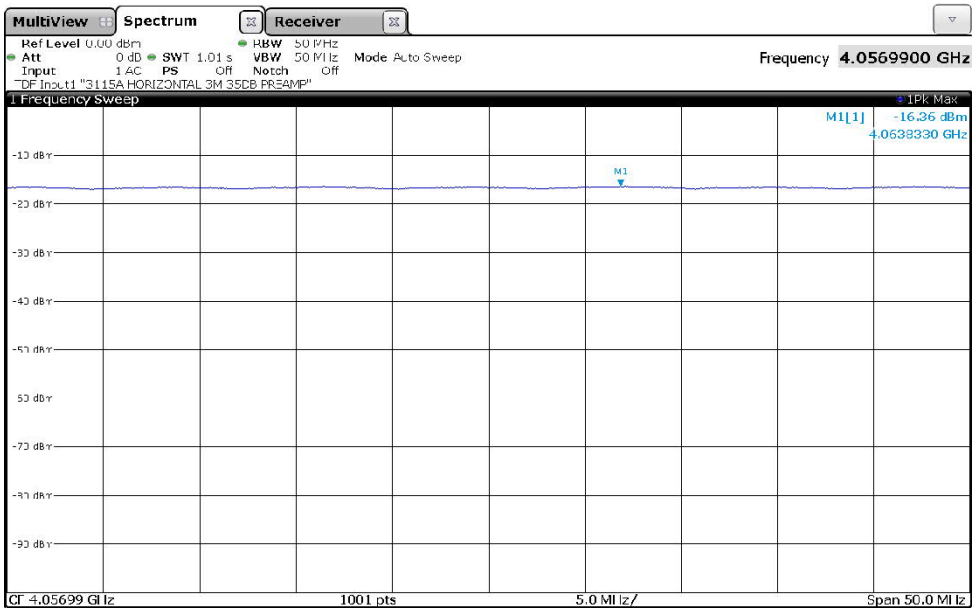
5.2.2 Test results (peak level of transmission)

Ambient temperature	22 °C	Relative humidity	60 %

191168_2.png: Peak level of transmission on channel 1:

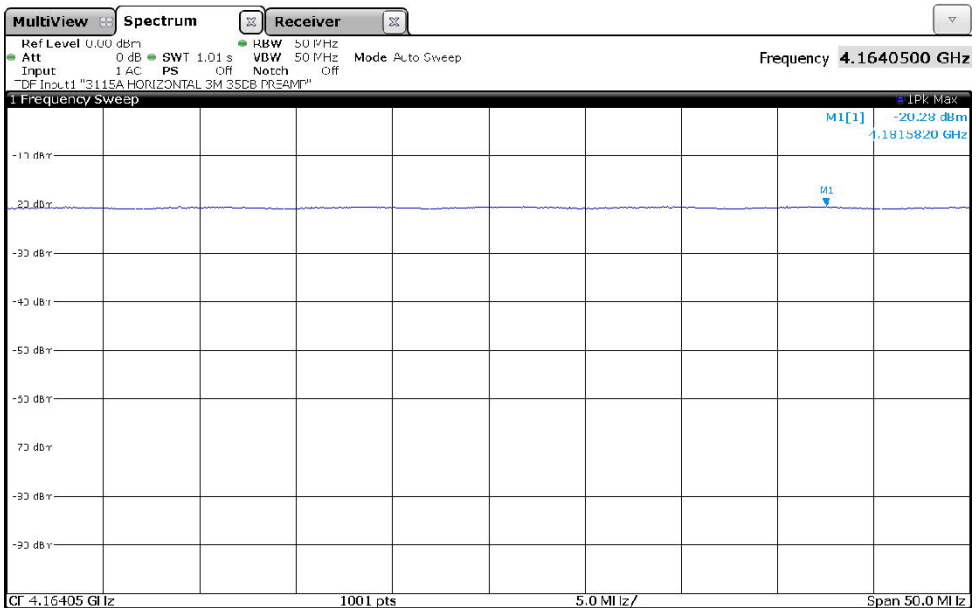


191168_4.png: Peak level of transmission on channel 2:



191168_6.png: Peak level of transmission on channel 3:

191168_8.png: Peak level of transmission on channel 4:



Channel No.	Channel frequency [GHz]	Frequency of max. level [GHz]	Bandwidth [kHz]	Height [cm]	Turn table [deg]	Turn device [deg]	Pol.	Peak level (EIRP) [dBm]	Limit [dBm]	Margin [dB]
1	3575	3626.699	50000	150	88	6	Hor.	-16.8	0.0	16.9
2	4000	4063.833	50000	150	89	8	Hor.	-16.4	0.0	16.4
3	4500	4407.560	50000	150	89	10	Hor.	-16.4	0.0	16.4
4	4000	4181.582	50000	150	84	15	Hor.	-20.3	0.0	20.3
Measurement uncertainty						±5.5 dB				

Test: Passed

Test equipment used (refer clause 6):

11 - 19, 26

5.3 Radiated emissions

5.3.1 Method of measurement (radiated emissions)

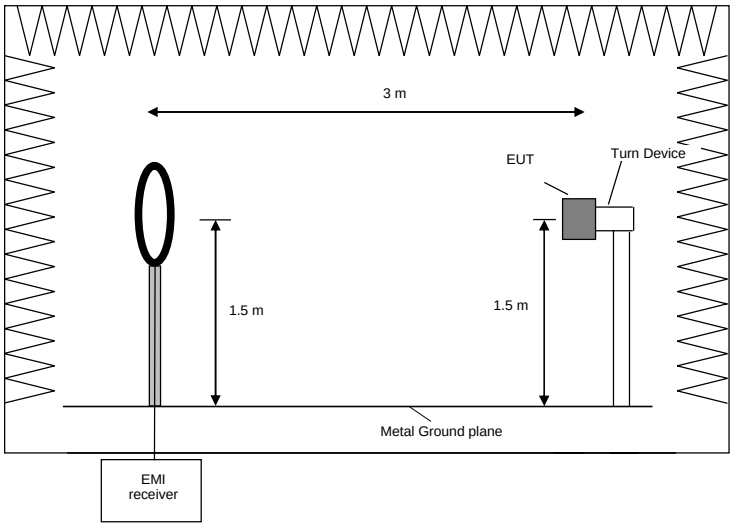
The radiated emission measurement is subdivided into five stages.

- A preliminary measurement carried out inside a semi anechoic chamber with various antenna heights in the frequency range 9 kHz to 1 GHz.
- A final measurement carried out on an outdoor test site without reflecting ground plane and fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A final measurement carried out inside a semi anechoic chamber with reflecting ground plane and various antenna height in the frequency range 30 MHz to 1 GHz.
- A preliminary measurement carried out in a fully anechoic chamber with fixed antenna distance and height in the frequency range above 1 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range above 1 GHz.

The frequency range 9 kHz to 30 MHz will be monitored with a spectrum analyser while the system and its cables will be manipulated to find out the configuration with the maximum emission levels if applicable. The EMI Receiver will be set to MAX Hold mode. The EUT and the measuring antenna will be rotated around their vertical axis to find the maximum emissions.

The resolution bandwidth of the spectrum analyser will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	300 Hz
150 kHz to 30 MHz	10 kHz



Preliminary measurement procedure:

Prescans were performed in the frequency range 9 kHz to 30 MHz.

The following procedure will be used:

1) Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2) Manipulate the system cables within the range to produce the maximum level of emission.
3) Rotate the EUT by 360 ° to maximize the detected signals.
4) Make a hardcopy of the spectrum.
5) Measure the frequencies of highest detected emission with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
6) Repeat steps 1) to 5) with the other orthogonal axes of the EUT.
7) Rotate the measuring antenna and repeat steps 1) to 5).

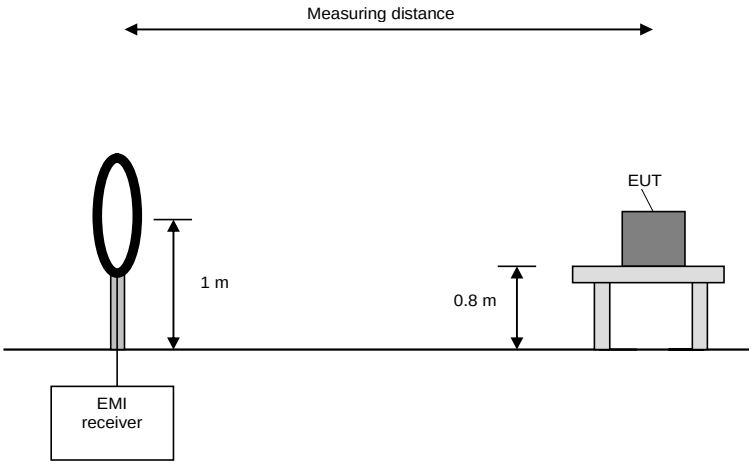
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in a measuring distances of 3 m, 10 m and 30 m whichever is appropriate. In the case where larger measuring distances were required the results will be extrapolated based on the values measured on the closer distances according to [2]. The final measurement will be performed with a EMI Receiver set to Quasi Peak.

On the during the preliminary measurement detected frequencies the final measurement will be performed while rotating the EUT and the measuring antenna in the range of 0 ° to 360 ° around their vertical axis until the maximum value is found.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz



Final measurement procedure:

The following procedure will be used:

1) Monitor the frequency range with the measuring antenna at vertical orientation parallel to the EUT at an azimuth of 0 °.
2) Rotate the EUT by 360 ° to maximize the detected signals and note the azimuth and orientation.
3) Rotate the measuring antenna to find the maximum and note the value.
4) Rotate the measuring antenna and repeat steps 1) to 3) until the maximum value is found.
5) Repeat steps 1) to 4) with the other orthogonal axes of the EUT (only if the EUT is a module or is used in a handheld application).

Preliminary and final measurement (30 MHz to 1 GHz)

The EUT is measured in the frequency range from 30 MHz to 1 GHz inside a semi anechoic chamber with a metal ground plane, which has been validated to the requirements of [1]. It is placed on a 3D-positioner to allow different positions at a distance of 3 meters from the receiving antenna. Both polarizations (vertical and horizontal) have been evaluated and the turn table has been turned to 360° to maximize the emissions. The receiving antenna is raised from 1 to 4 m.

Procedure preliminary measurement:

The following procedure is used:

1. Set the measurement antenna to 1 m height.
2. Monitor the frequency range at vertical polarization and a EUT azimuth of 0 °.
3. Rotate the EUT by 360° to maximize the detected signals in two axes.
4. Repeat 1) to 2) with the horizontal polarization of the measuring antenna.
5. Increase the height of the antenna for 0.5 m and repeat steps 2 – 4 until the final height of 4 m is reached (30 MHz to 1 GHz only).
6. The highest values for each frequency will be saved by the software, including the antenna height, measurement antenna polarization and turntable azimuth for that value.

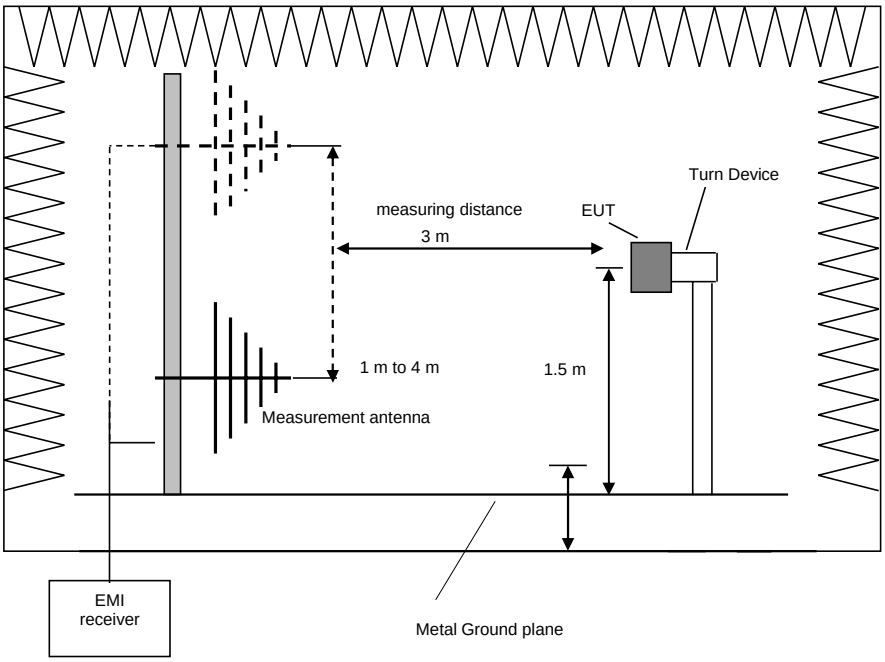
Procedure final measurement:

The following procedure is used:

1. Select the highest frequency peaks to the limit for the final measurement.
2. The software will determine the exact peak frequencies by doing a partial scan with reduced RBW with +/- 10 times the RBW of the pre-scan of the selected peaks.
3. If the EUT is portable or ceiling mounted, find the worst case EUT position (x, y, z) for the final test.
4. The worst measurement antenna height is found by the measurement software by varying the measurement antenna height by +/- 0.5 m from the value obtained in the preliminary measurement, and to monitor the emission level.
5. The worst azimuth turntable position is found by varying the turntable azimuth by +/- 25° from the value obtained in the preliminary measurement, and to monitor the emission level.
6. The final measurement is performed at the worst-case antenna height and the worst case turntable azimuth
7. Steps 2 – 6 will be repeated for each frequency peak selected in step 1.
8. For frequencies above 960 MHz the measured field strength is converted to an EIRP value

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	100 kHz



Test setup for measurements below 1 GHz

Preliminary and final measurement (1 GHz to 26.5 GHz)

This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device at a height of 1.5 m. The set-up of the Equipment under test will be in accordance with [1].

Procedure preliminary measurement:

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °. This measurement is repeated after raising the EUT in 30 ° steps according 6.6.5.4 in [1].

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 26.5 GHz	1 MHz

Prescans were performed in the frequency range 1 to 26.5 GHz.

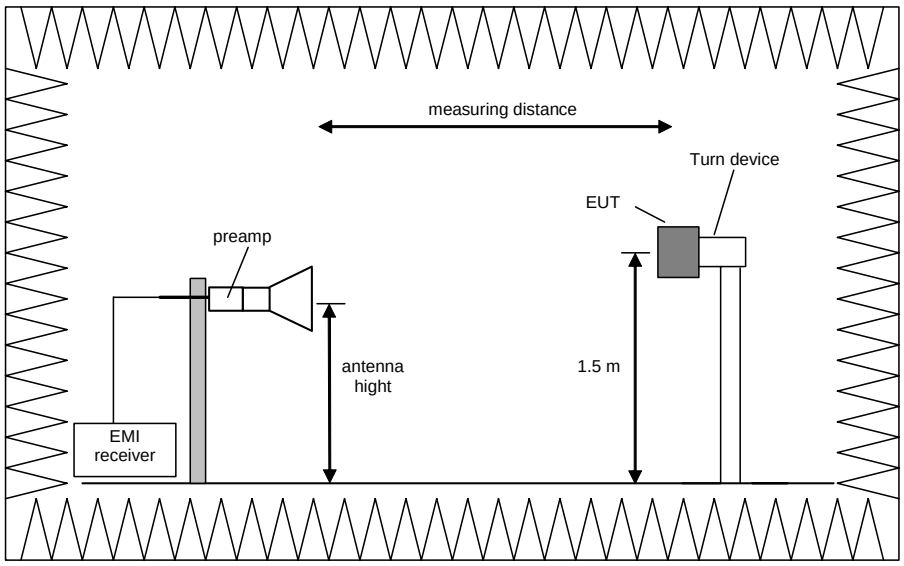
The following procedure will be used:

1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 ° with peak or RMS detector of the spectrum analyser (depending of the noise floor and the applicable limit).
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an angle of 30° (60°, 90°, 120° and 150°) according to 6.6.5.4 in [1].
6. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
7. The measurement antenna polarisation, with the according EUT position (Turntable and Turn device) which produces the highest emission for each frequency will be used for the final measurement. The six closest values to the applicable limit will be used for the final measurement.

Procedure final measurement:

The measurements were performed in the frequency range 1 GHz to 26.5 GHz.
The following procedure will be used:

1) Set the turntable and the turn device to obtain the worst-case emission for the first frequency identified in the preliminary measurements.
2) Set the measurement antenna polarisation to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
3) Set the spectrum analyser to EMI mode with peak and RMS average detector activated.
4) Rotate the turntable from 0° to 360° to find the EUT angle that produces the highest emissions.
5) Note the highest displayed peak and average values
6) Repeat the steps 1) to 5) for each frequency detected during the preliminary measurements.
7) Replace the EUT by a substitution antenna, which is fed by a signal generator.
8) Carry out a substitution for each frequency detected during the steps 5) to 6).
9) Calculate the EIRP values with the help of the final measurement and the substitution results.



Test setup for measurements from 1 GHz to 26.5 GHz

Preliminary and final measurement (26.5 GHz to 40 GHz)

The measurement will be performed in horizontal and vertical polarisation of the measuring antenna, the antenna close to the EUT and while moving the antenna over all sides of the EUT.

The resolution bandwidth of the EMI Receiver will be set to the following values:

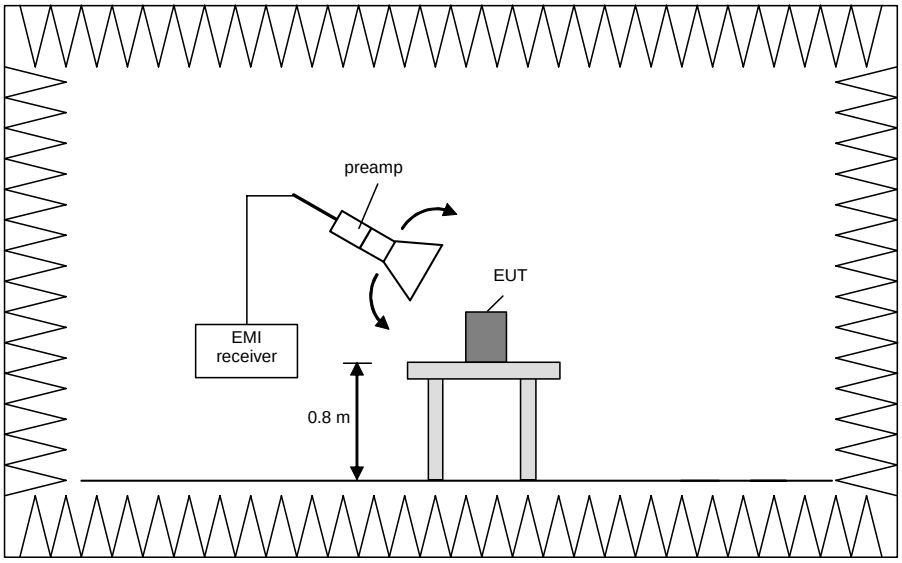
Frequency range	Resolution bandwidth
26.5 GHz to 40 GHz	1 MHz

Procedure of measurement:

The following procedure will be used:

1) Monitor the frequency range at horizontal polarisation and move the antenna over all sides of the EUT (if necessary, move the EUT to another orthogonal axis).
2) Change the antenna polarisation and repeat 1) with vertical polarisation.
3) Make a hardcopy of the spectrum.
4) Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
5) Change the analyser mode to Clear / Write and found the cone of emission.
6) Rotate and move the EUT, so that the measuring distance can be enlarged to 3 m and the antenna will be still inside the cone of emission.
7) Measure the level of the detected frequency with the correct resolution bandwidth, with the antenna polarisation and azimuth and the peak and RMS average detector, which causes the maximum emission.
8) Repeat steps 1) to 7) for the next antenna spot if the EUT is larger than the antenna beamwidth.
9) Replace the EUT by a substitution antenna, which is fed by a signal generator.
10) Carry out a substitution for each frequency detected during the steps 5) to 6).
11) Calculate the EIRP values with the help of the final measurement and the substitution results.

Step 1) to 6) are defined as preliminary measurement.



Test setup for measurements from 26.5 GHz to 40 GHz

5.3.2 Test results (radiated emissions)

5.3.2.1 Preliminary radiated emission measurement (9 kHz to 10 GHz)

Ambient temperature	21 °C	Relative humidity	55 %

Position of EUT: The EUT was set-up on a turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m (9 kHz to 1 GHz), 1 m (1 GHz to 26.5 GHz) and 0.3 m (26.5 GHz to 40 GHz).

Cable guide: For detail information of test set-up refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied by a fully charged battery.

Frequency range: The preliminary measurement was carried out in the frequency range 9 kHz to 40 GHz according to [2].

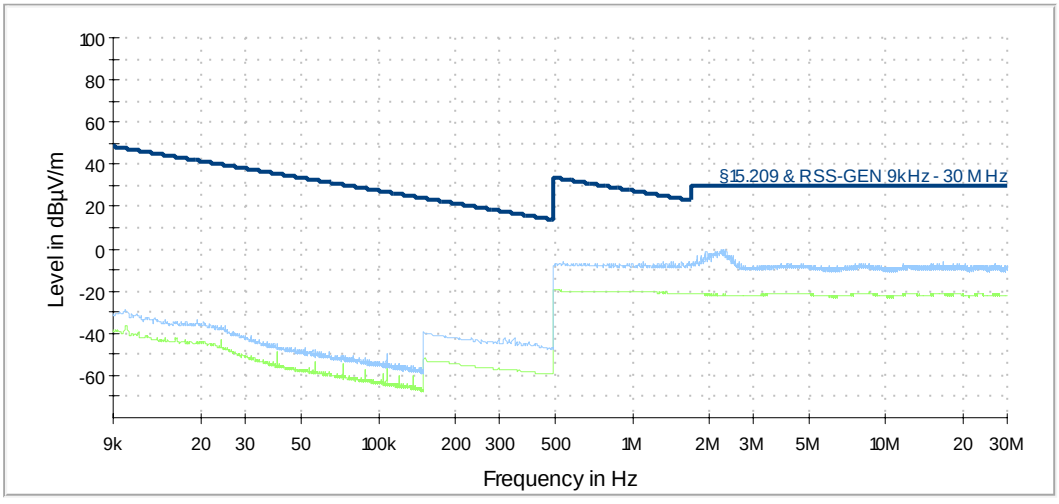
Remark: As the measurements have shown, no emissions above the noise floor of the measurement system were emitted by the EUT below 1 GHz.

It was agreed between the applicant and the laboratory to test the EUT as handheld device according to FCC 47 CFR Part 15.519. After testing was completed it was clarified by the FCC, that the device can be certified as indoor device according to FCC 47 CFR Part 15.517. So, the limits in the plots on the following pages showing the more stringent limits of the FCC 47 CFR Part 15.519.

Transmitter independent emissions below 1 GHz:

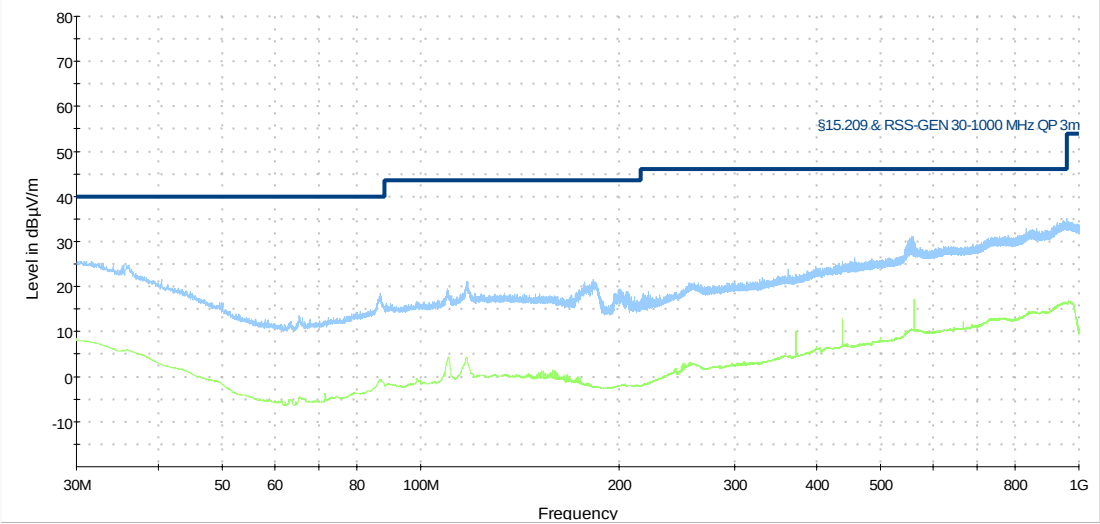
191168_11_mag: Spurious emissions from 9 kHz to 30 MHz (operation mode 1):

Remark: In the shown plot a distance correction factor was added to the measurement results to account for the different measuring distances according to standard (9 kHz to 490 kHz @ 300 m; 490 kHz to 30 MHz @ 30 m).



All emissions are more the 20 dB from the limit, so no final measurement was performed.

191168_11_SAC: Spurious emissions from 30 MHz to 1 GHz (operation mode 1):



The emissions in this frequency range were caused by the camera system of the semi anechoic chamber and not by the EUT.

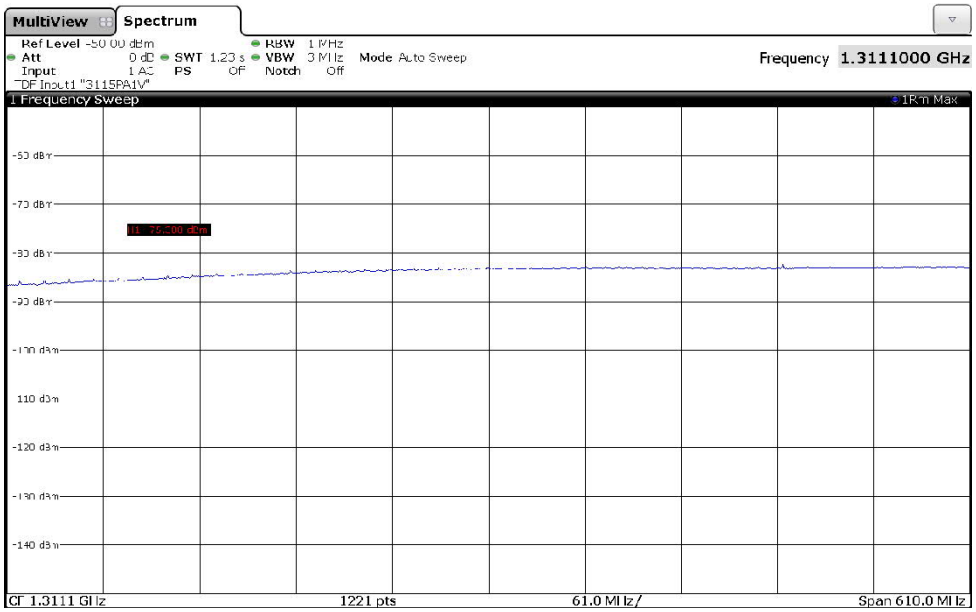
The following frequency was found in the frequency range 960 MHz to 1 GHz:

- 962.975 MHz (highest peak, noise floor of the measuring system).

On this frequency a final measurement has to be carried out. The result is presented in the following.

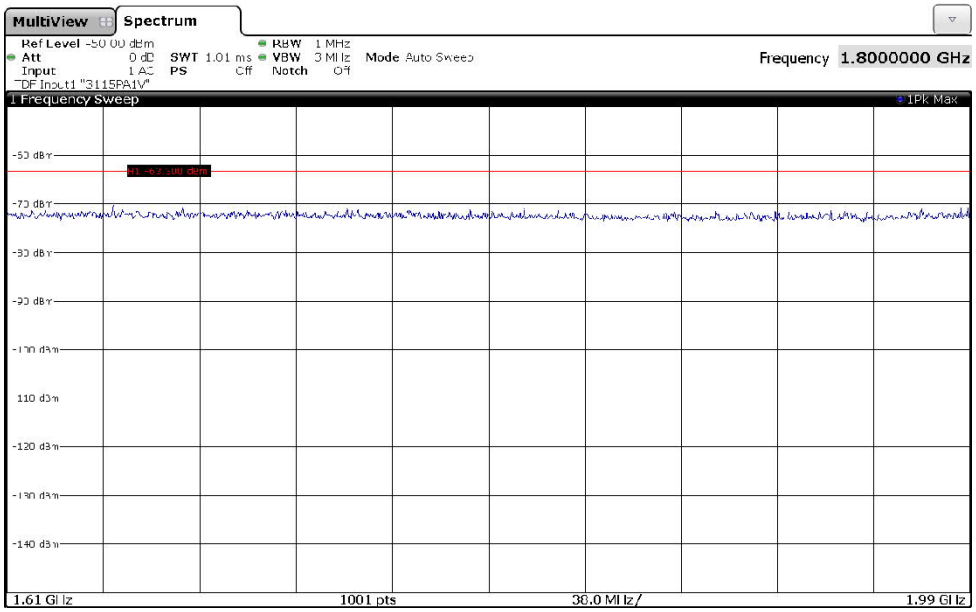
Transmitter operates on channel 1 (operation mode 1):

191168_13.png: Transmitter spurious emissions from 1 GHz to 1.61 GHz (operation mode 1):



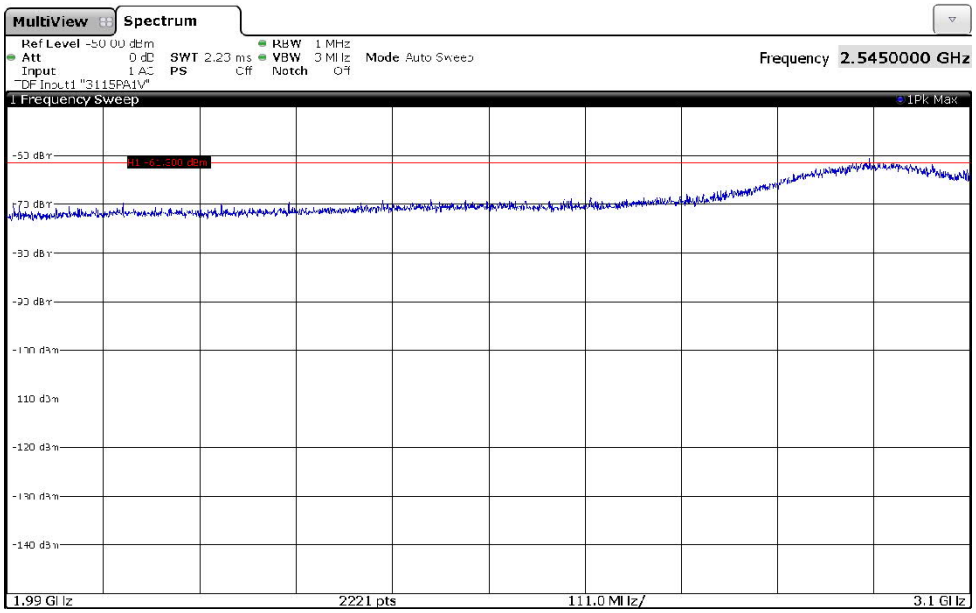
All emissions were below -82.7 dBm. This peak value is already below the rms AV-limit of -75.3 dBm.

191168_14.png: Transmitter spurious emissions from 1.61 GHz to 1.99 GHz (operation mode 1):



All emissions were below -70.1 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -53.3 dBm.

191168_15.png: Transmitter spurious emissions from 1.99 GHz to 3.1 GHz (operation mode 1):

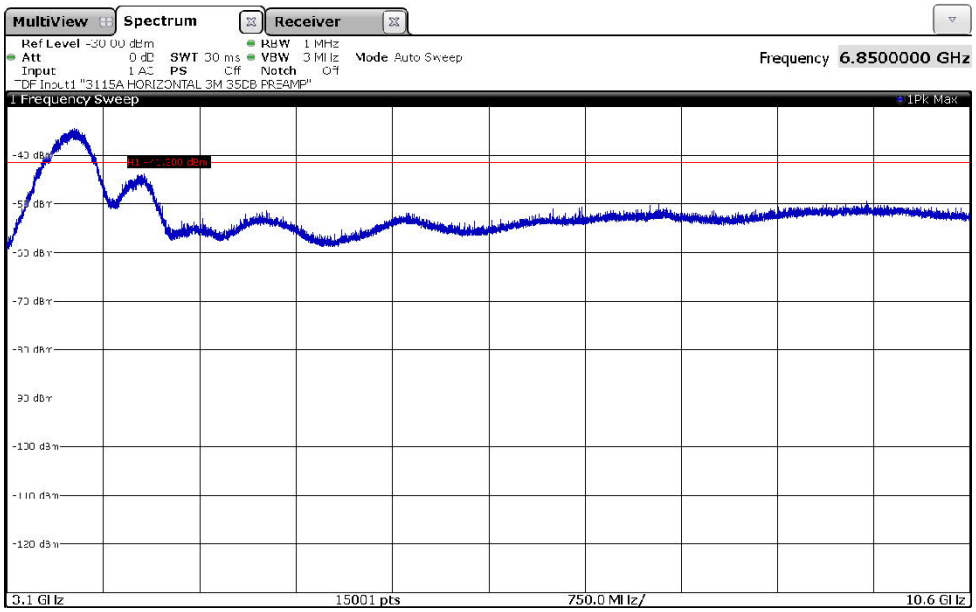


The following frequencies were found:

- 1996.799 MHz and 3009.011 MHz.

On these frequencies a final measurement has to be carried out. The result is presented in the following. All other emissions were below -68.1 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm.

191168_9.png: Transmitter spurious emissions from 3.1 GHz to 10.6 GHz (operation mode 1):

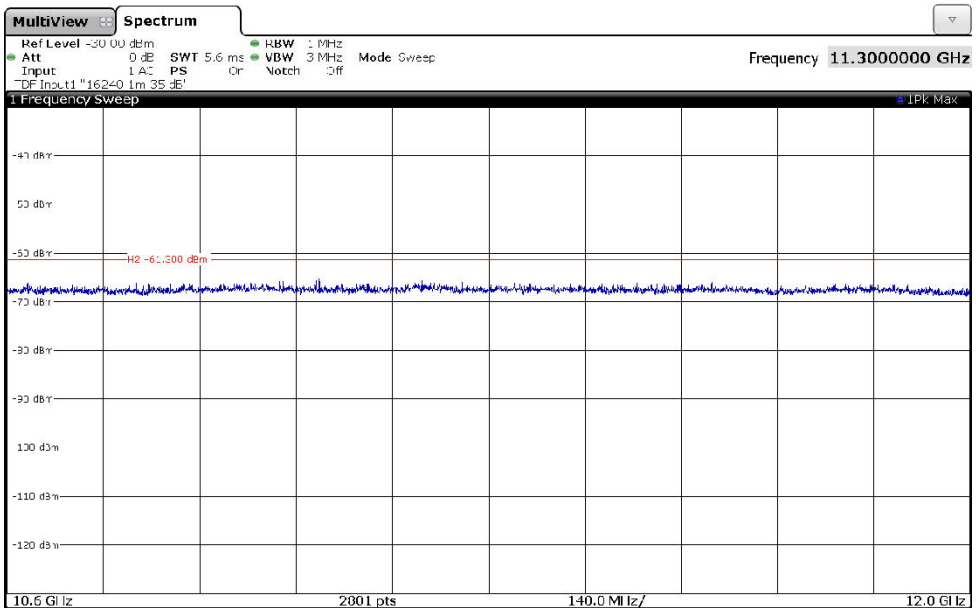


The following frequencies were found:

- 3633.890MHz (wanted signal) and 4139.870 MHz .

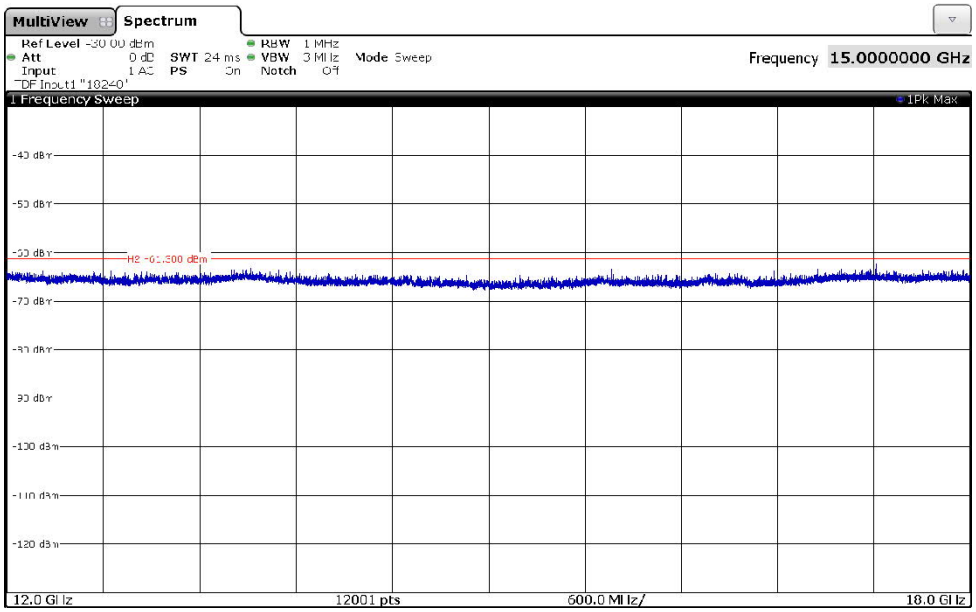
On this frequency a final measurement has to be carried out. The result is presented in the following. All other emissions were below -49.8 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -41.3 dBm.

191168_33.png: Transmitter spurious emissions from 10.6 GHz to 12 GHz (operation mode 1):



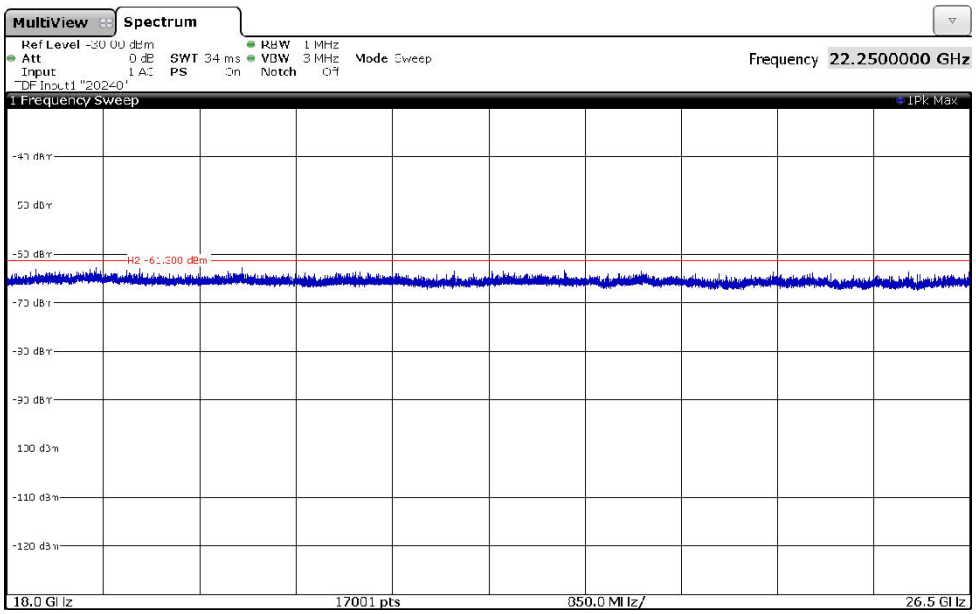
All emissions were below -65.4 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_37.png: Transmitter spurious emissions from 12 GHz to 18 GHz (operation mode 1):



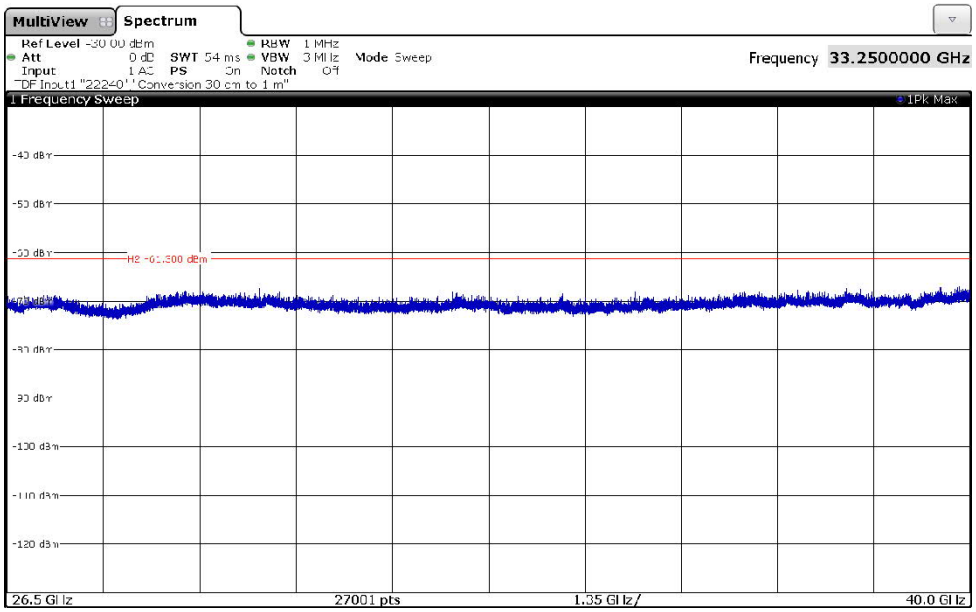
All emissions were below -62.4 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_38.png: Transmitter spurious emissions from 18 GHz to 26.5 GHz (operation mode 1):



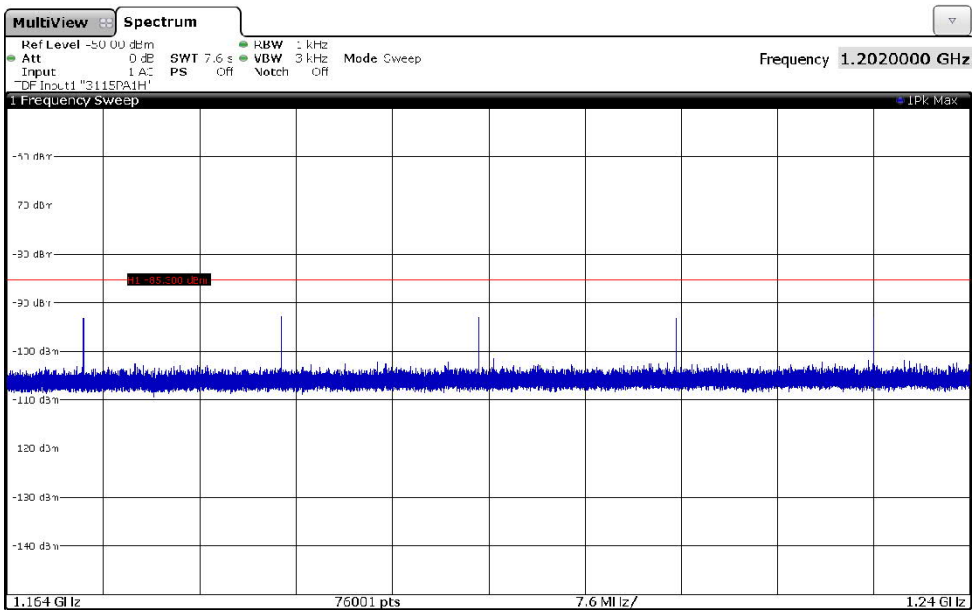
All emissions were below -62.8 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_45.png: Transmitter spurious emissions from 26.5 GHz to 40 GHz (operation mode 1):



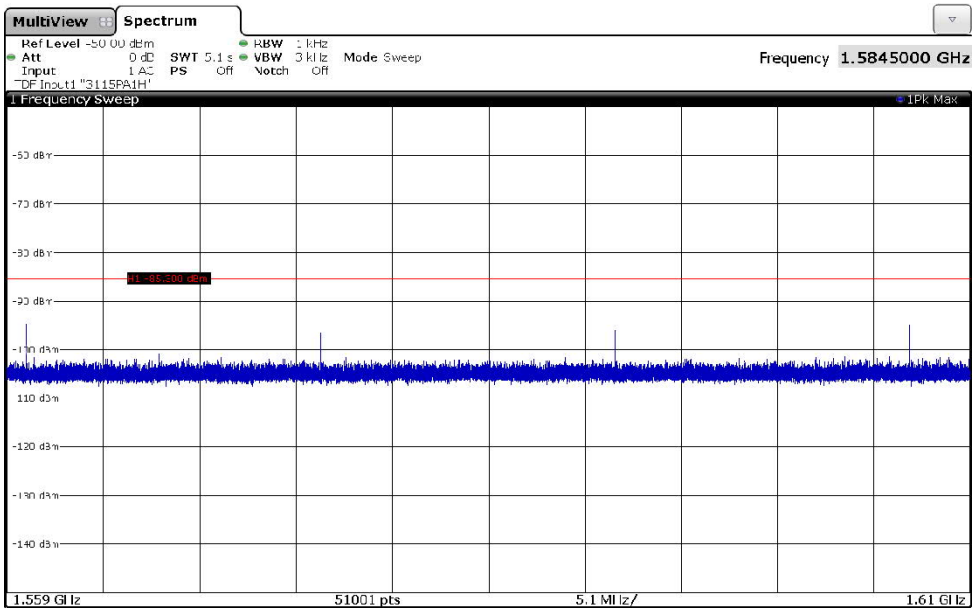
All emissions were below -66.9 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_16.png: Transmitter spurious emissions from 1.164 GHz to 1.240 GHz (operation mode 1):



All emissions were below -92.9 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -85.3 dBm. Therefore, no final measurement was carried out in this frequency range.

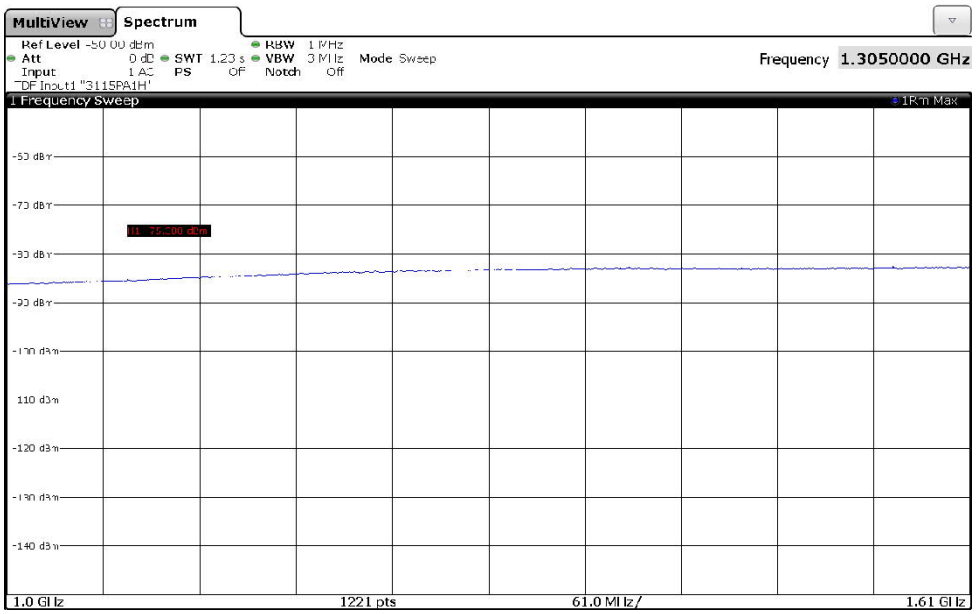
191168_17.png: Transmitter spurious emissions from 1.559 GHz to 1.610 GHz (operation mode 1):



All emissions were below -95.1 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -85.3 dBm. Therefore, no final measurement was carried out in this frequency range.

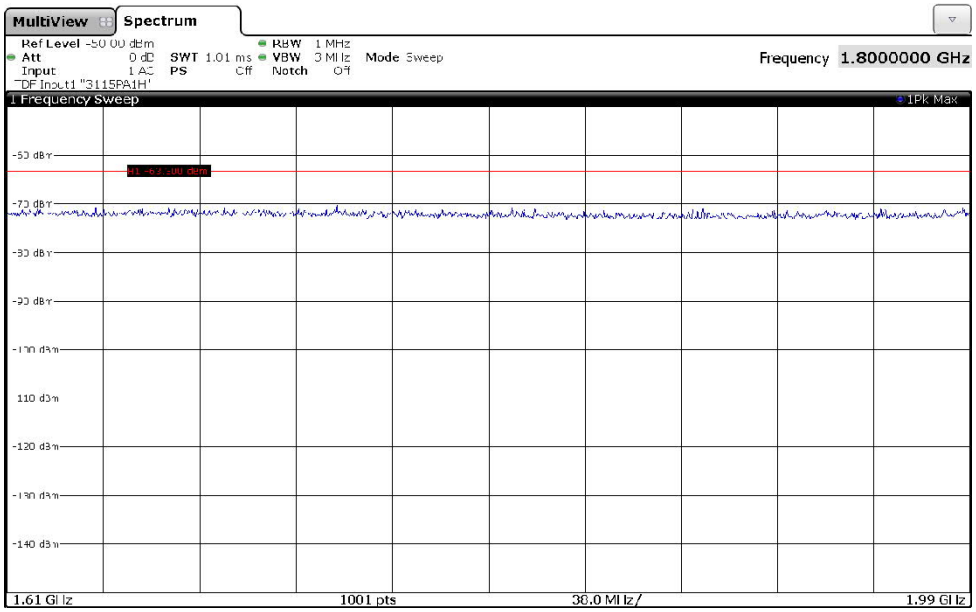
Transmitter operates on channel 2 (operation mode 2):

191168_18.png: Transmitter spurious emissions from 1 GHz to 1.61 GHz (operation mode 2):



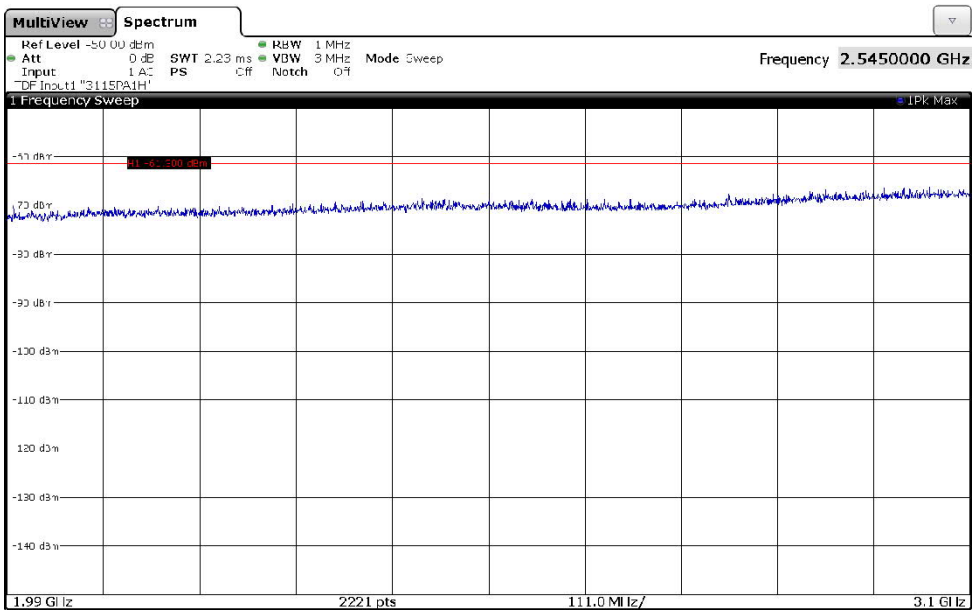
All emissions were below -82.6 dBm. This peak value is already below the rms AV-limit of -75.3 dBm.

191168_19.png: Transmitter spurious emissions from 1.61 GHz to 1.99 GHz (operation mode 2):



All emissions were below -70.3 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -53.3 dBm.

191168_20.png: Transmitter spurious emissions from 1.99 GHz to 3.1 GHz (operation mode 2):

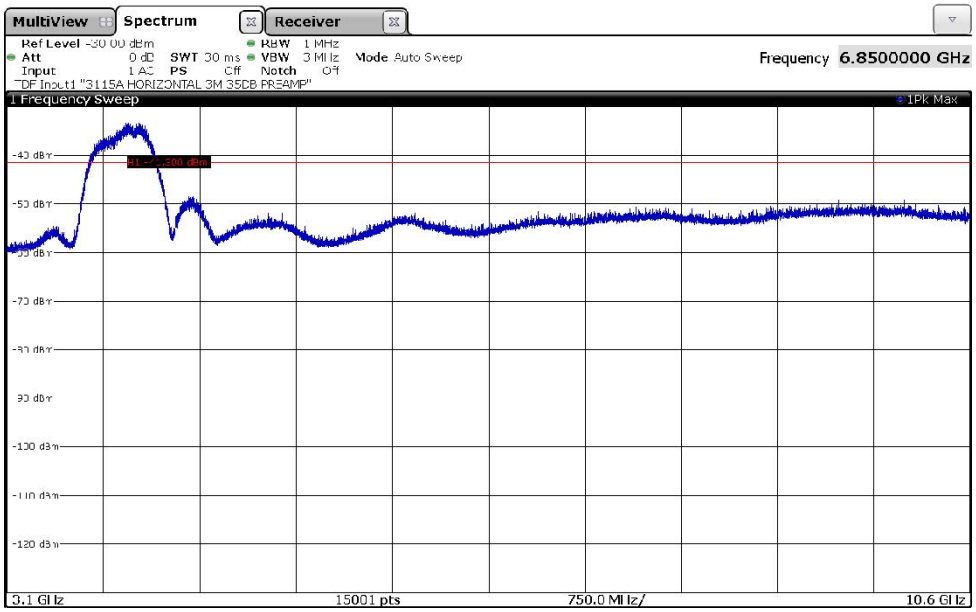


The following frequency was found:

- 1996.799 MHz.

On this frequency a final measurement has to be carried out. The result is presented in the following. All other emissions were below -66.3 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm.

191168_10.png: Transmitter spurious emissions from 3.1 GHz to 10.6 GHz (operation mode 2):

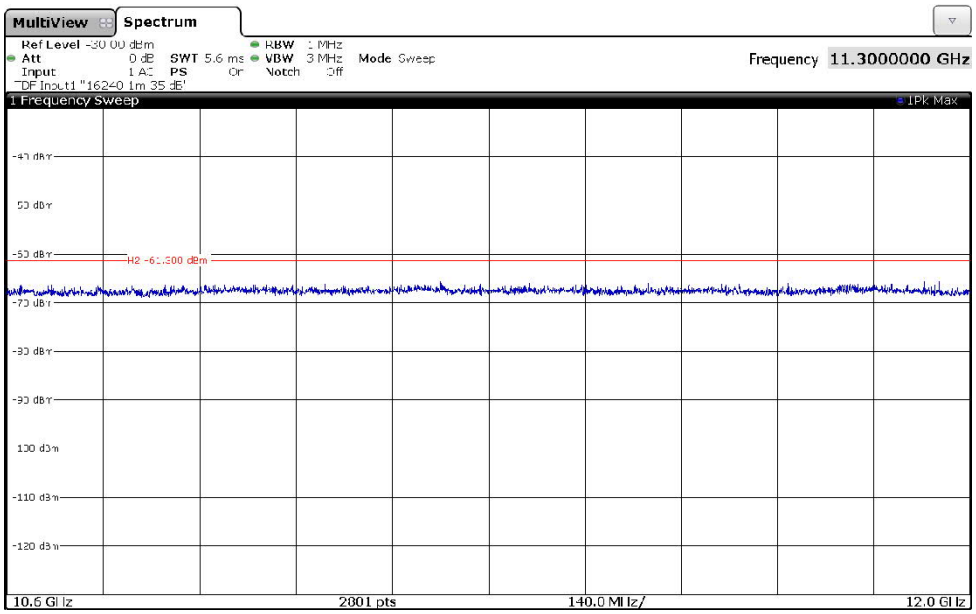


The following frequency was found:

- 4055.990 MHz (wanted signal).

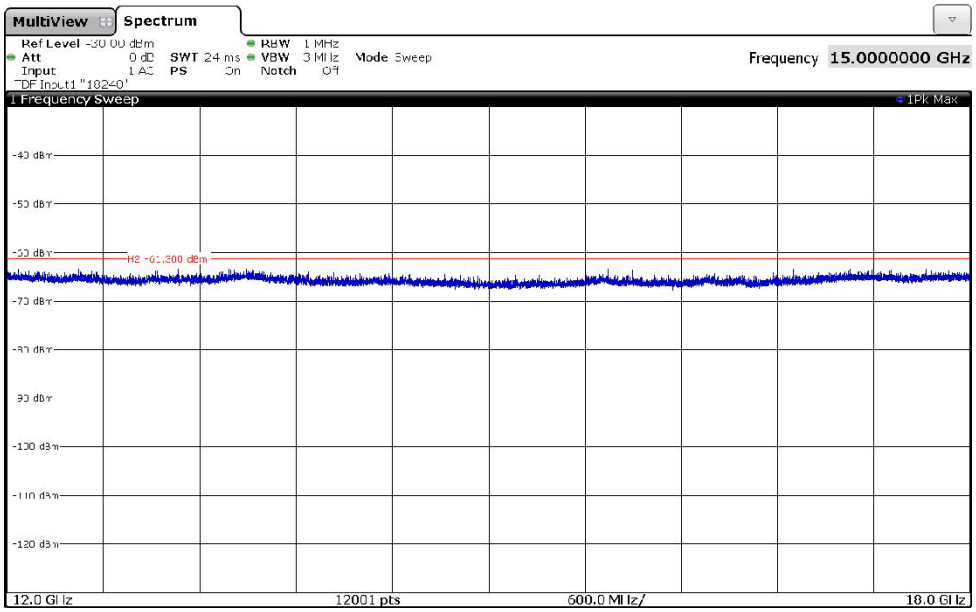
On this frequency a final measurement has to be carried out. The result is presented in the following. All other emissions were below -47.4 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -41.3 dBm.

191168_34.png: Transmitter spurious emissions from 10.6 GHz to 12 GHz (operation mode 2):



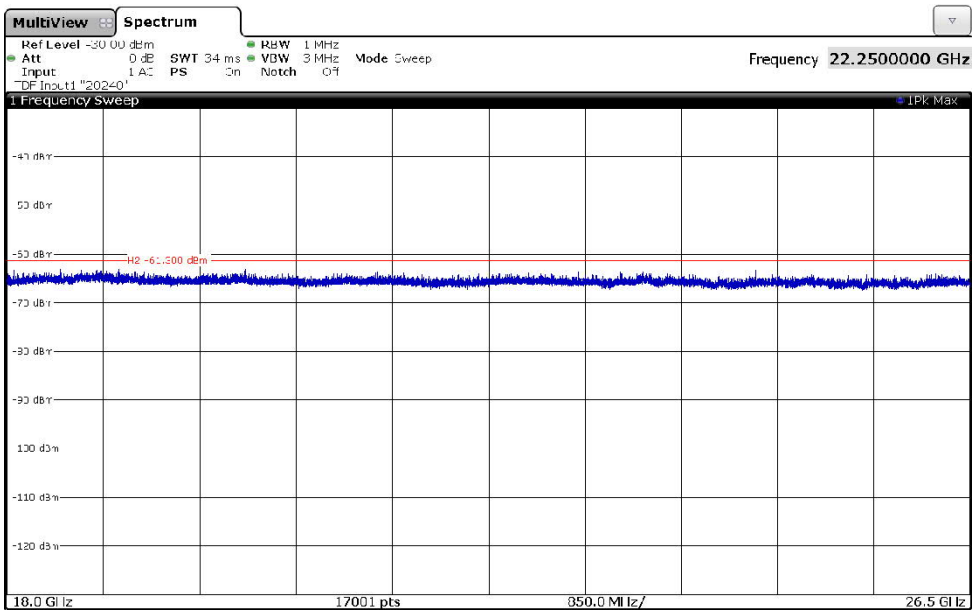
All emissions were below -65.7 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_40.png: Transmitter spurious emissions from 12 GHz to 18 GHz (operation mode 2):



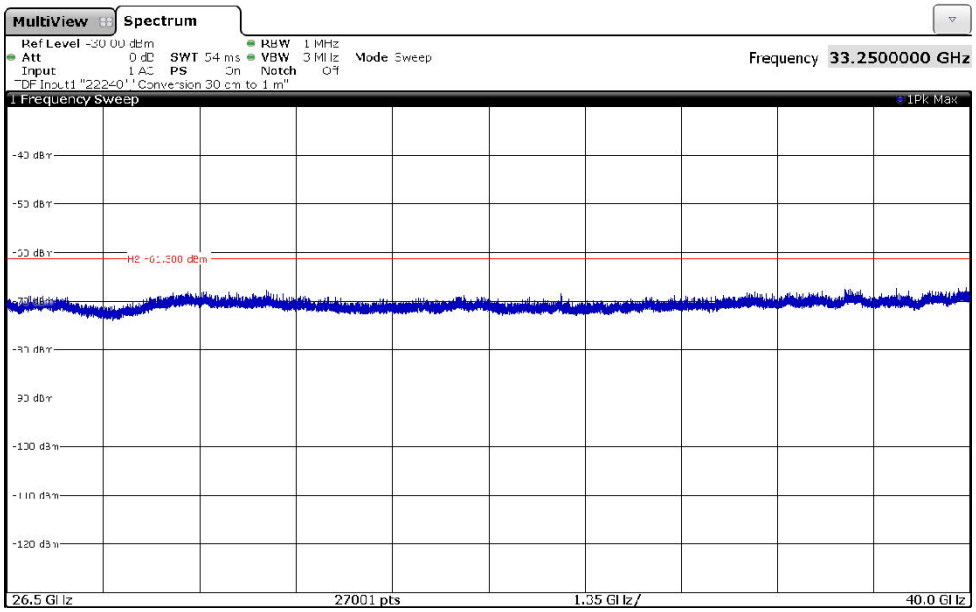
All emissions were below -63.2 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_39.png: Transmitter spurious emissions from 18 GHz to 26.5 GHz (operation mode 2):



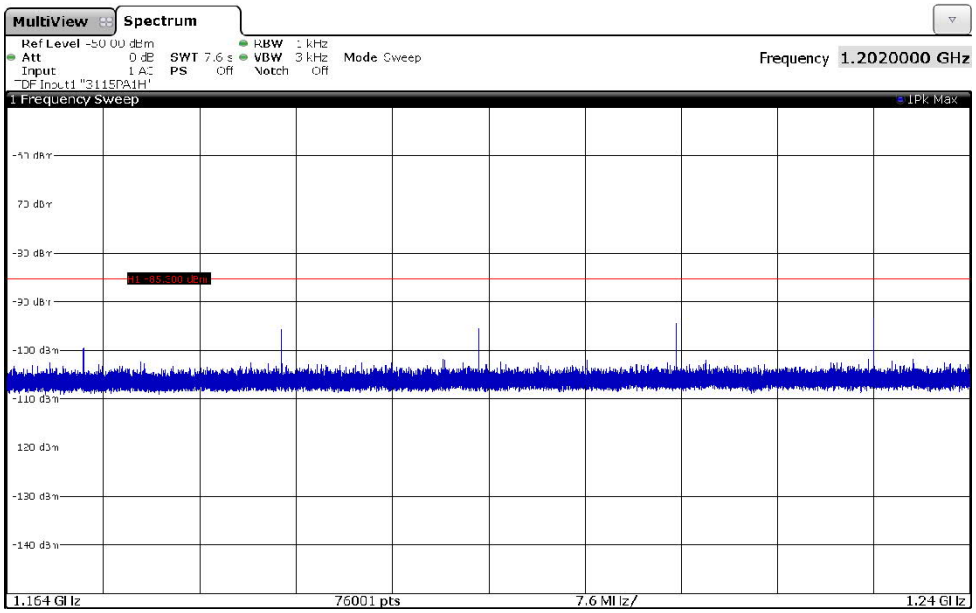
All emissions were below -63.1 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_46.png: Transmitter spurious emissions from 26.5 GHz to 40 GHz (operation mode 2):



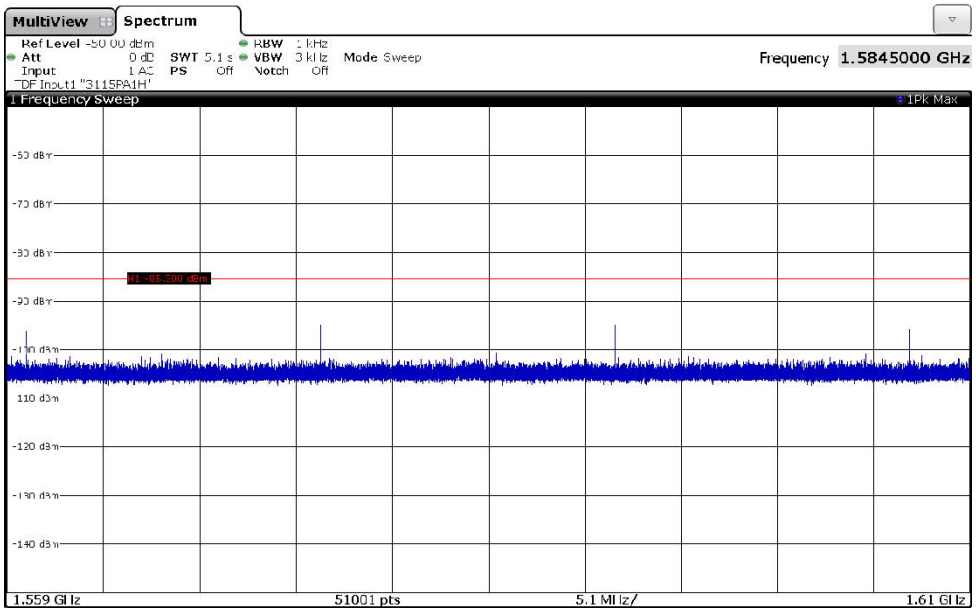
All emissions were below -67.3 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_21.png: Transmitter spurious emissions from 1.164 GHz to 1.240 GHz (operation mode 2):



All emissions were below -93.5 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -85.3 dBm. Therefore, no final measurement was carried out in this frequency range.

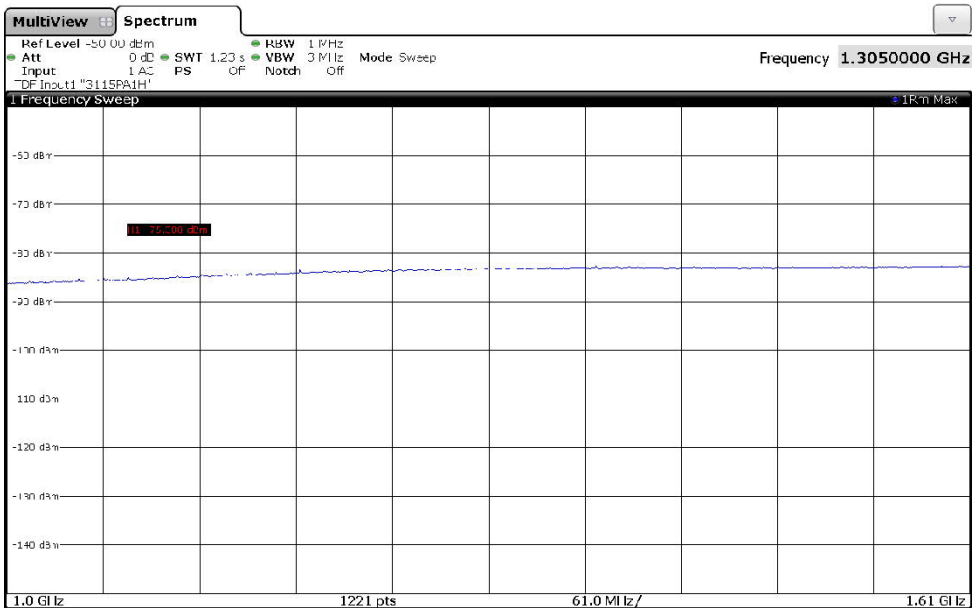
191168_22.png: Transmitter spurious emissions from 1.559 GHz to 1.610 GHz (operation mode 2):



All emissions were below -94.9 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -85.3 dBm. Therefore, no final measurement was carried out in this frequency range.

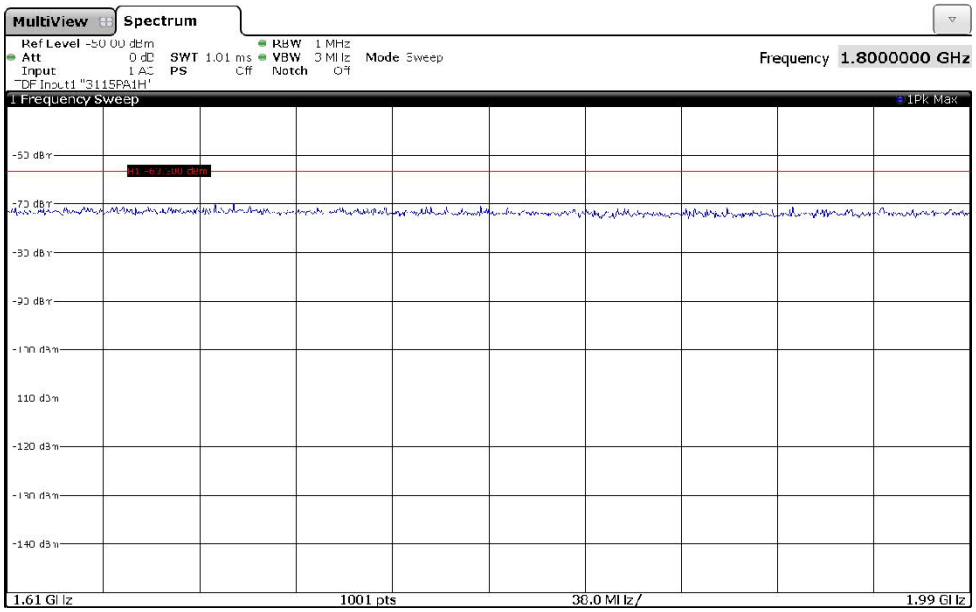
Transmitter operates on channel 3 (operation mode 3):

191168_25.png: Transmitter spurious emissions from 1 GHz to 1.61 GHz (operation mode 3):



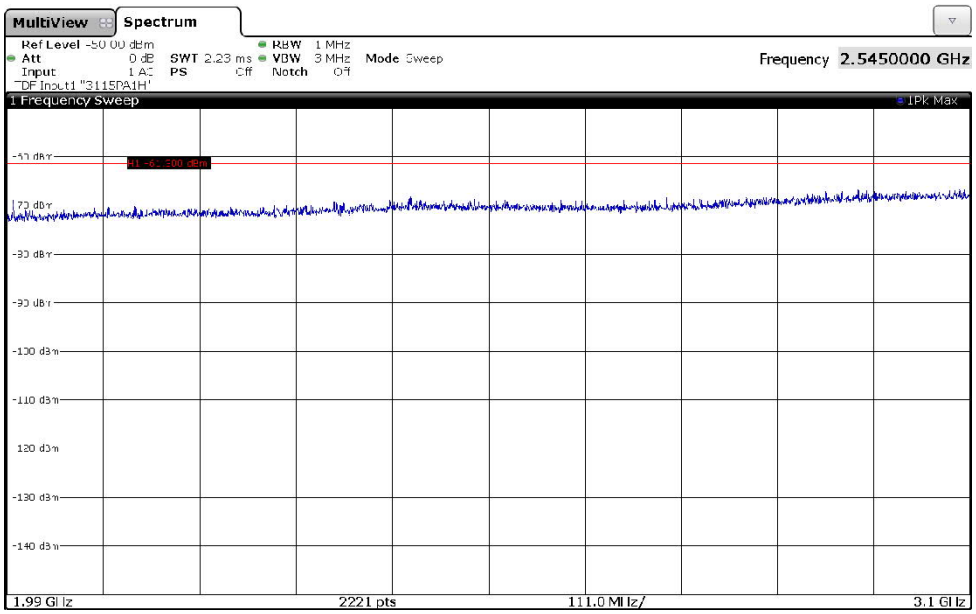
All emissions were below -82.7 dBm. This peak value is already below the rms AV-limit of -75.3 dBm.

191168_26.png: Transmitter spurious emissions from 1.61 GHz to 1.99 GHz (operation mode 3):



All emissions were below -69.9 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -53.3 dBm.

19116_27.png: Transmitter spurious emissions from 1.99 GHz to 3.1 GHz (operation mode 3):

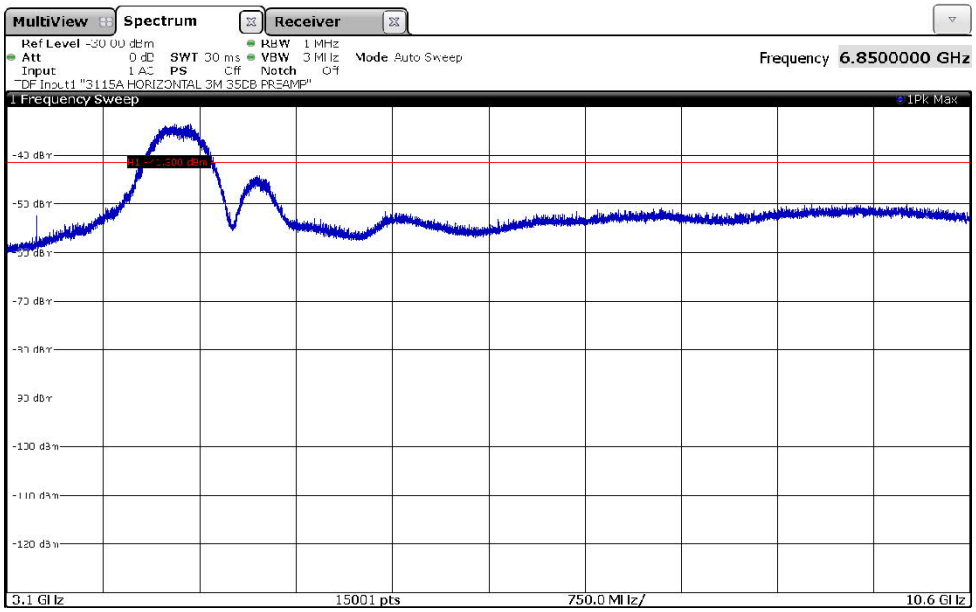


The following frequency was found:

- 1996.799 MHz.

On this frequency a final measurement has to be carried out. The result is presented in the following. All other emissions were below -66.8 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm.

191168_11.png: Transmitter spurious emissions from 3.1 GHz to 10.6 GHz (operation mode 3):

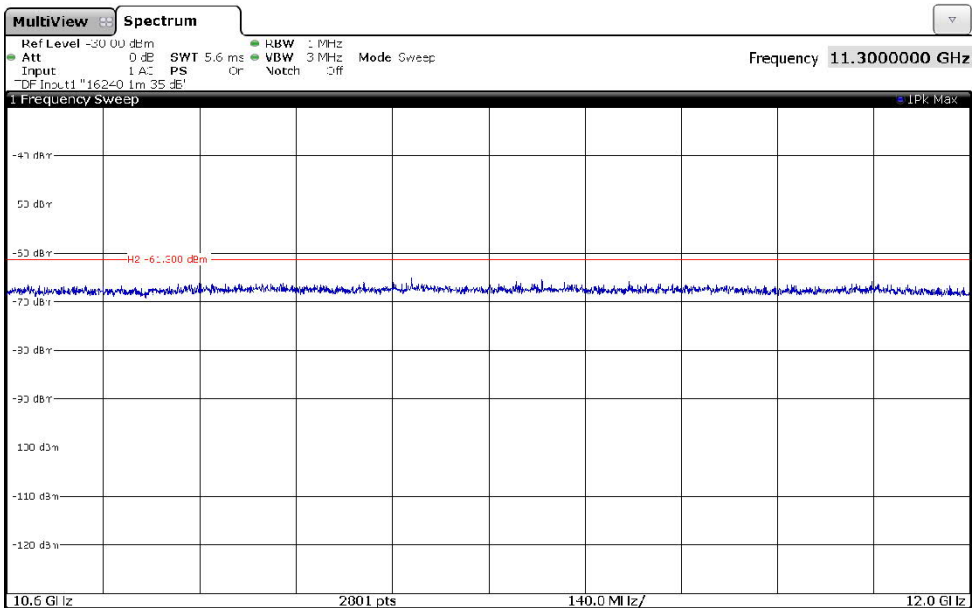


The following frequencies were found:

- 4423.600 MHz (wanted signal) and 5027.120 MHz.

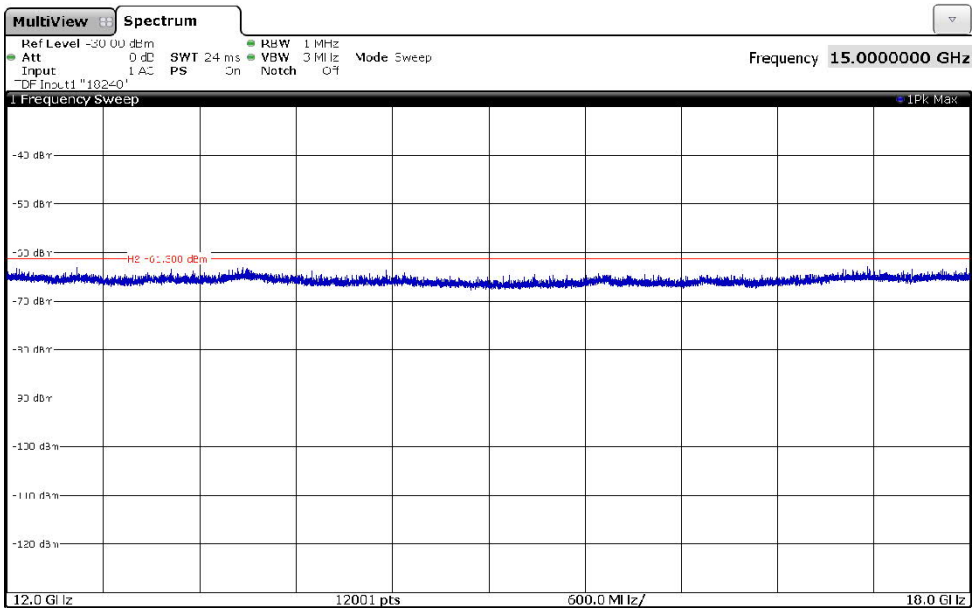
On these frequencies a final measurement has to be carried out. The results are presented in the following. All other emissions were below -50.3 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -41.3 dBm.

191168_35.png: Transmitter spurious emissions from 10.6 GHz to 12 GHz (operation mode 3):



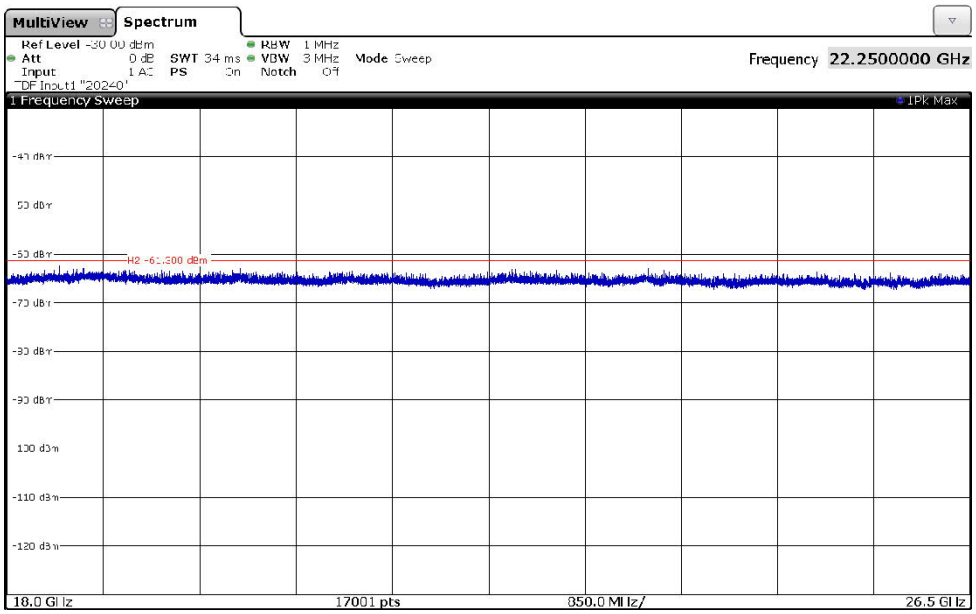
All emissions were below -65.1 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_41.png: Transmitter spurious emissions from 12 GHz to 18 GHz (operation mode 3):



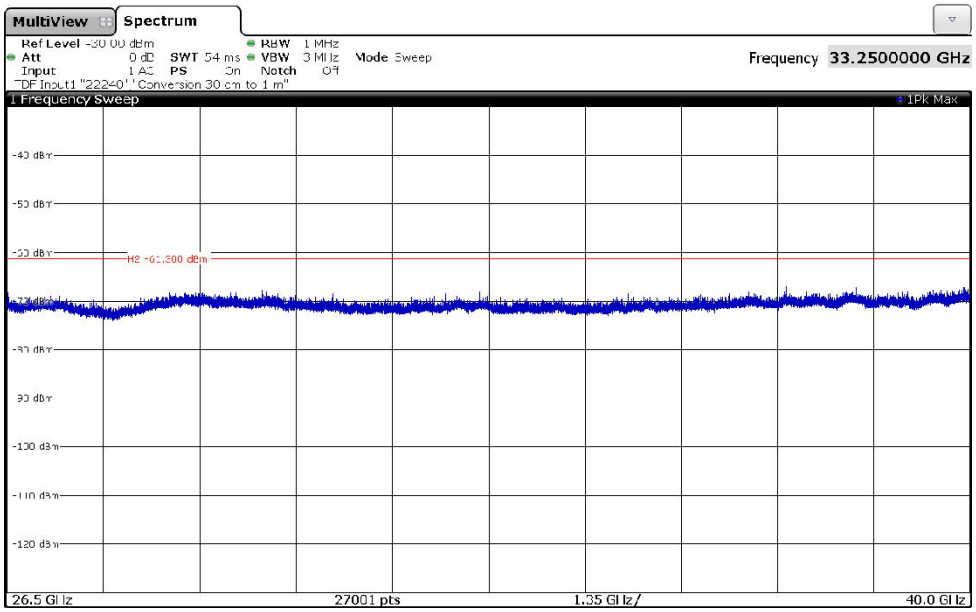
All emissions were below -62.9 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_42.png: Transmitter spurious emissions from 18 GHz to 26.5 GHz (operation mode 3):



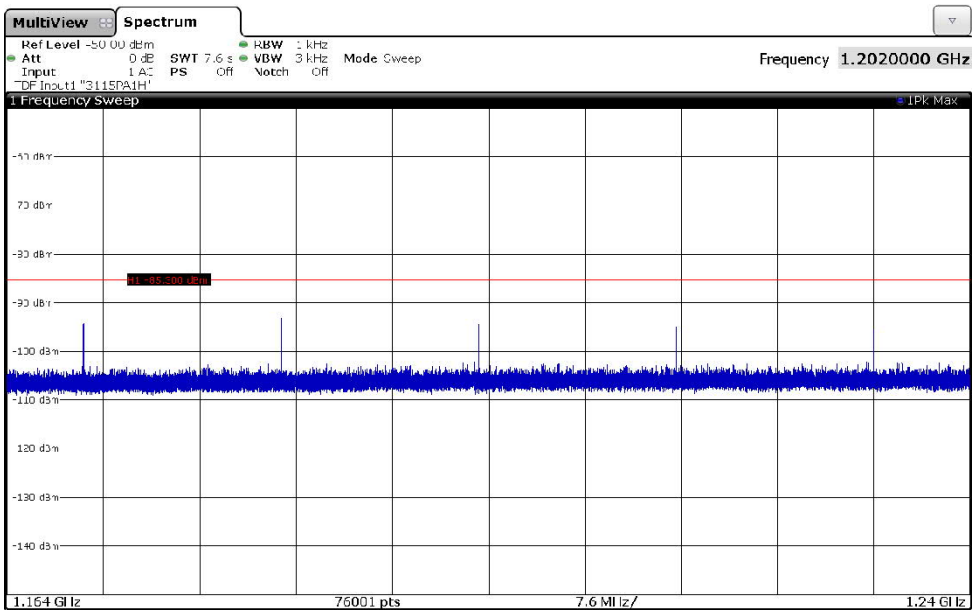
All emissions were below -62.4 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_47.png: Transmitter spurious emissions from 26.5 GHz to 40 GHz (operation mode 3):



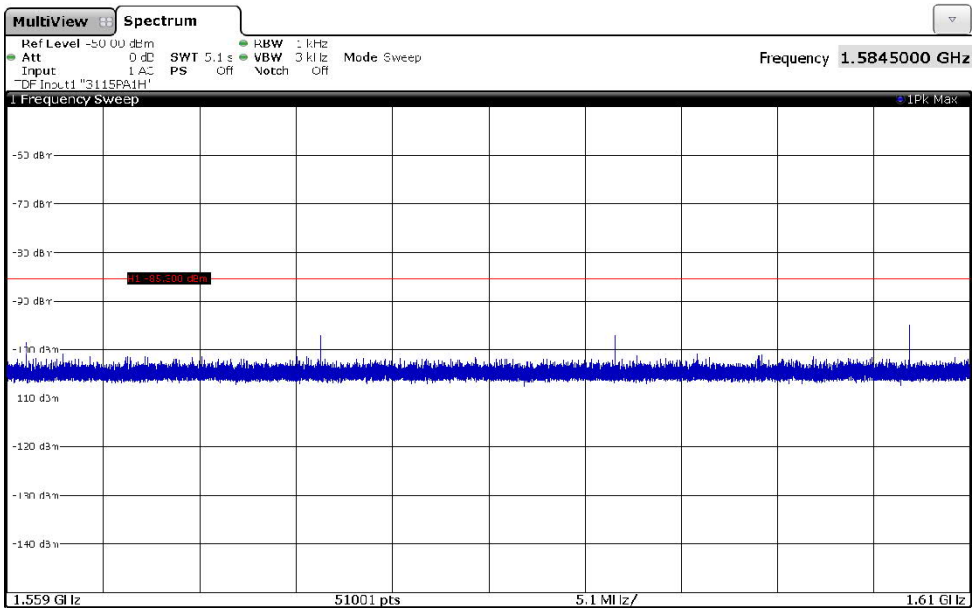
All emissions were below -67.1 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_24.png: Transmitter spurious emissions from 1.164 GHz to 1.240 GHz (operation mode 3):



All emissions were below -93.2 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -85.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_23.png: Transmitter spurious emissions from 1.559 GHz to 1.610 GHz (operation mode 3):



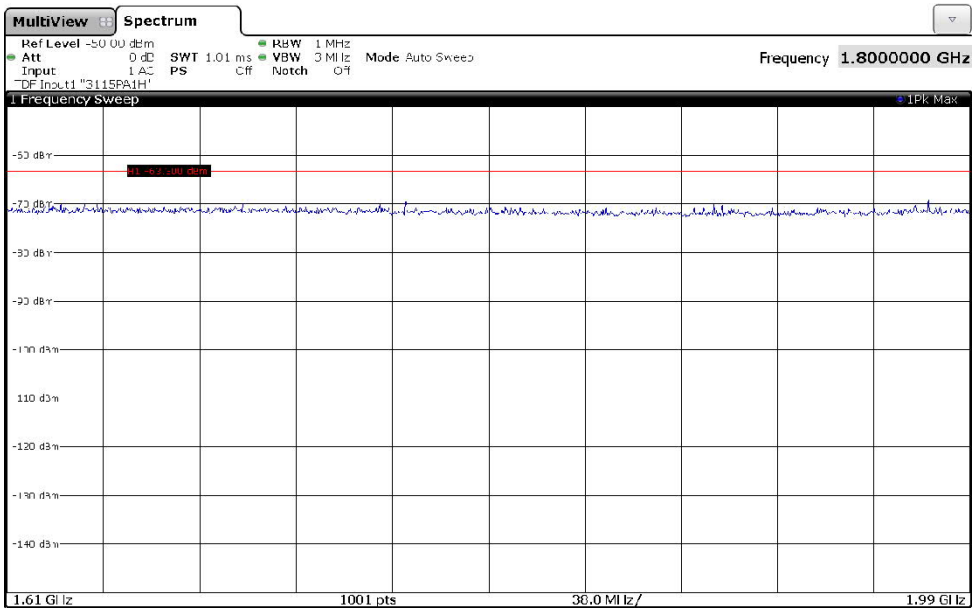
All emissions were below -95.0 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -85.3 dBm. Therefore, no final measurement was carried out in this frequency range.

Transmitter operates on channel 4 (operation mode 4):

191168_30.png: Transmitter spurious emissions from 1 GHz to 1.61 GHz (operation mode 4):

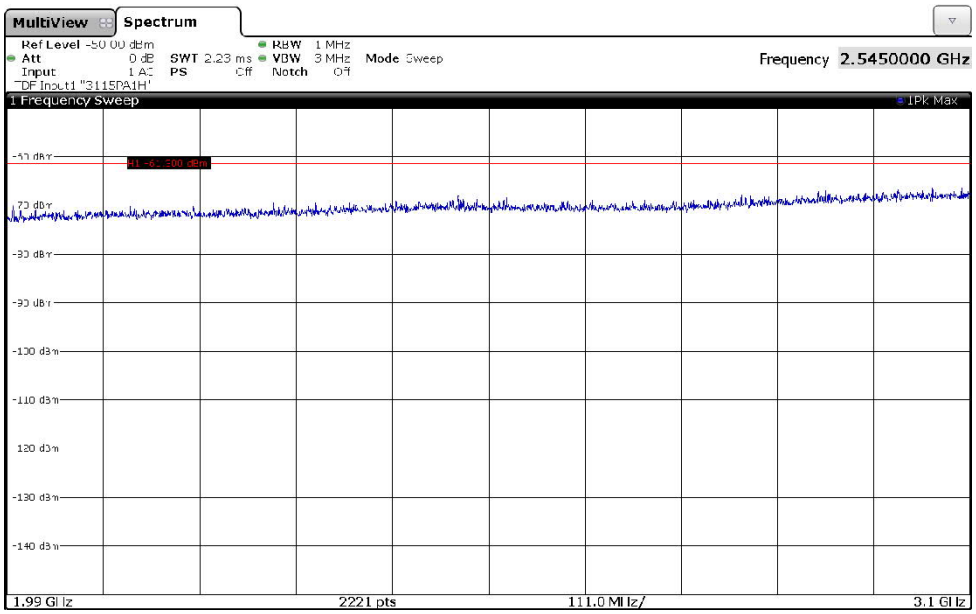
All emissions were below -82.7 dBm. This peak value is already below the rms AV-limit of -75.3 dBm.

191168_29.png: Transmitter spurious emissions from 1.61 GHz to 1.99 GHz (operation mode 4):



All emissions were below -69.1 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -53.3 dBm.

19116_28.png: Transmitter spurious emissions from 1.99 GHz to 3.1 GHz (operation mode 4):

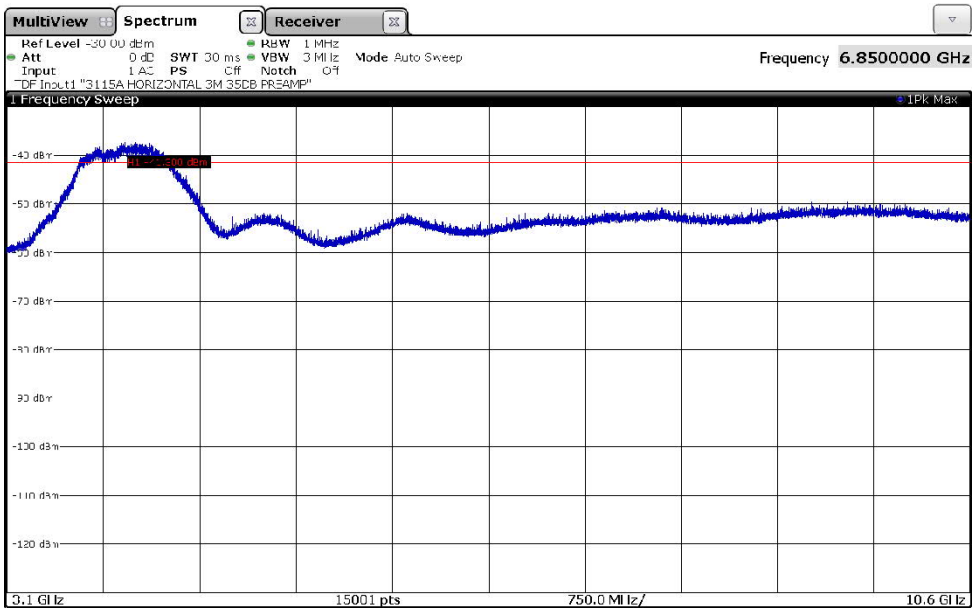


The following frequency was found:

- 1996.799 MHz.

On this frequency a final measurement has to be carried out. The result is presented in the following. All other emissions were below -66.4 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm.

19116_12.png: Transmitter spurious emissions from 3.1 GHz to 10.6 GHz (operation mode 4):

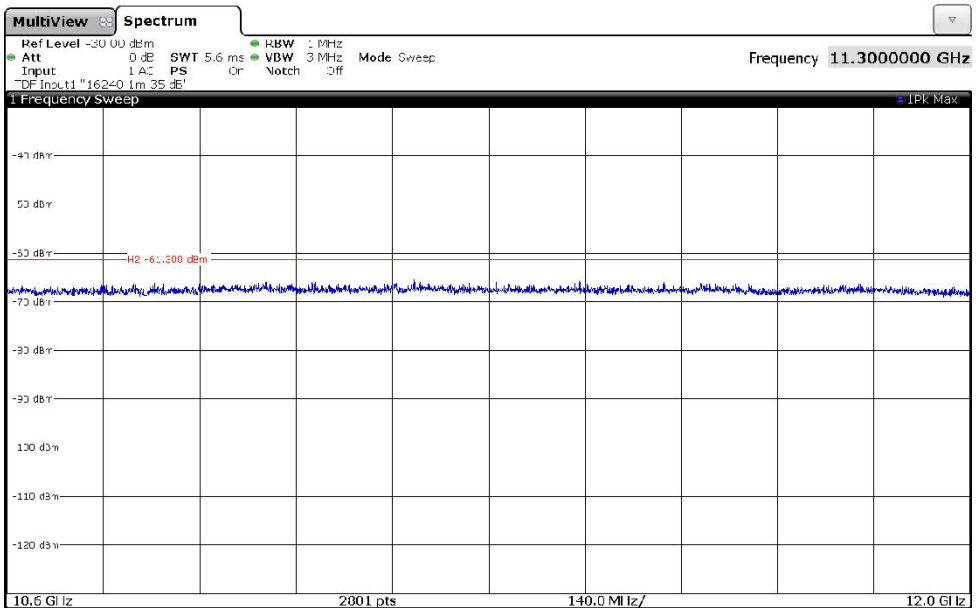


The following frequency was found:

- 4171.380 MHz (wanted signal).

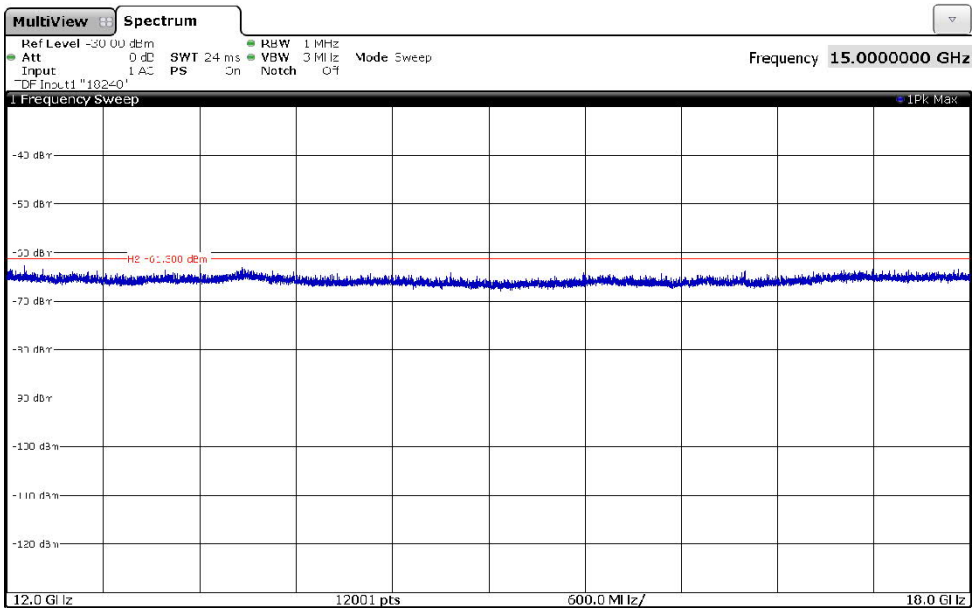
On this frequency a final measurement has to be carried out. The result is presented in the following. All other emissions were below -49.7 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -41.3 dBm.

191168_36.png: Transmitter spurious emissions from 10.6 GHz to 12 GHz (operation mode 4):



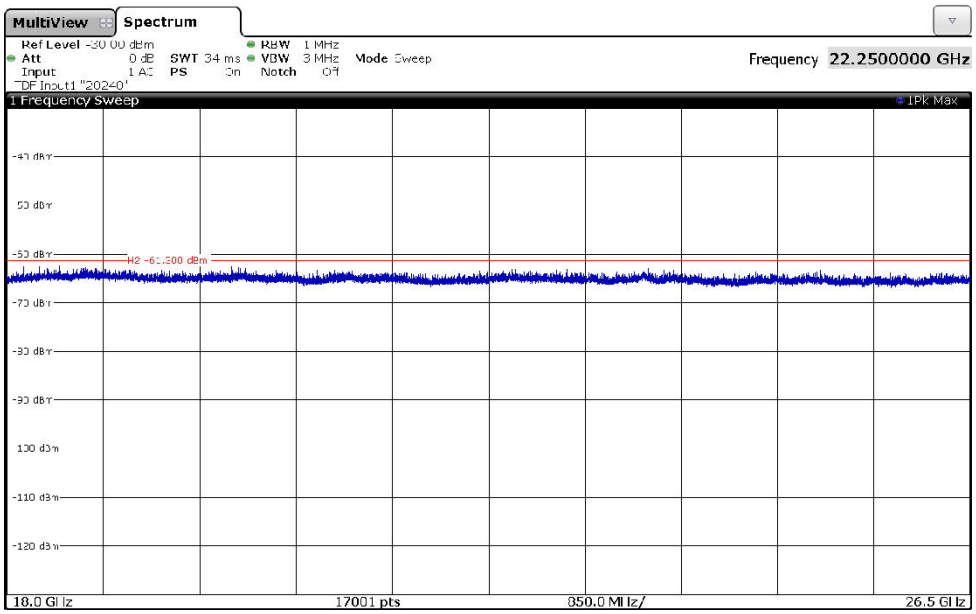
All emissions were below -65.6 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_44.png: Transmitter spurious emissions from 12 GHz to 18 GHz (operation mode 4):



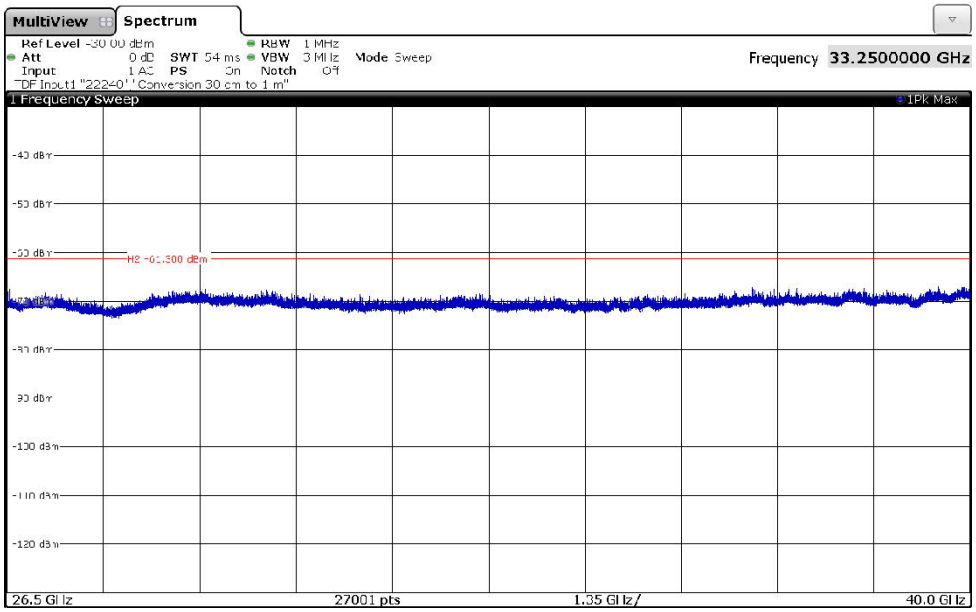
All emissions were below -62.7 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_43.png: Transmitter spurious emissions from 18 GHz to 26.5 GHz (operation mode 4):



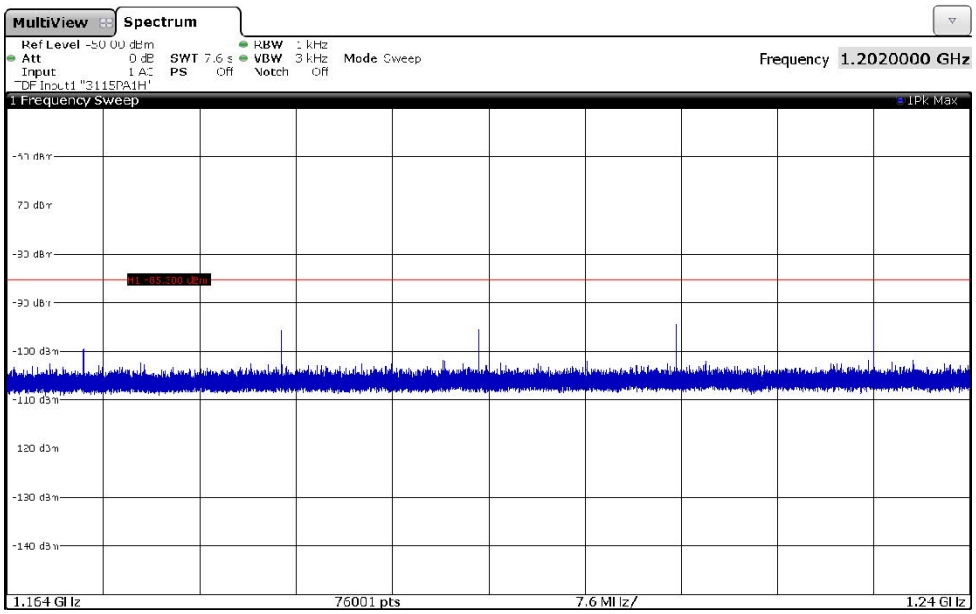
All emissions were below -62.4 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_48.png: Transmitter spurious emissions from 26.5 GHz to 40 GHz (operation mode 4):



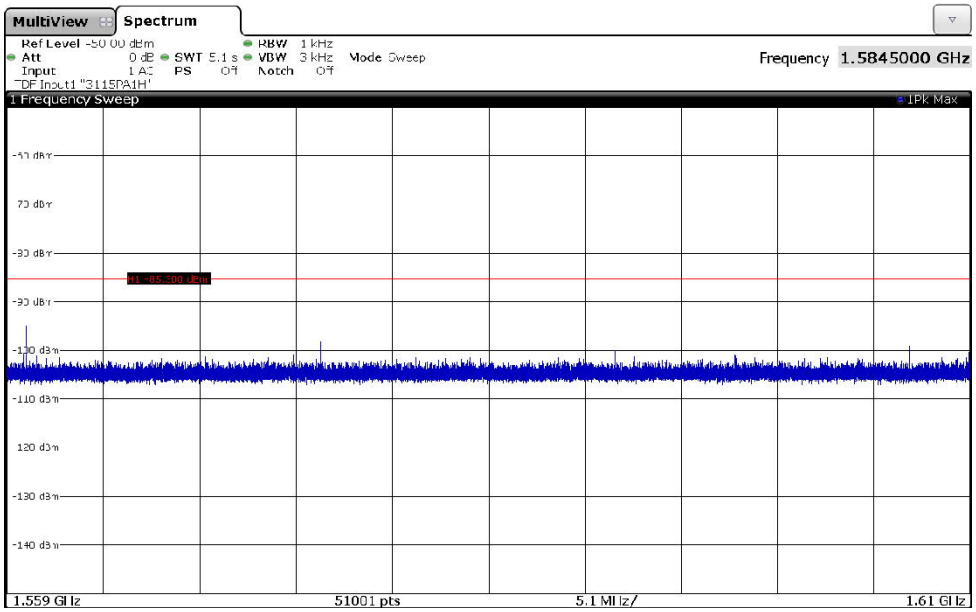
All emissions were below -66.9 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -51.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_32.png: Transmitter spurious emissions from 1.164 GHz to 1.240 GHz (operation mode 4):



All emissions were below -96.6 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -85.3 dBm. Therefore, no final measurement was carried out in this frequency range.

191168_31.png: Transmitter spurious emissions from 1.559 GHz to 1.610 GHz (operation mode 4):



All emissions were below -95.0 dBm (measured with peak detector). This peak value is already below the rms AV-limit of -85.3 dBm. Therefore, no final measurement was carried out in this frequency range.

Test equipment used (refer clause 6):

1 – 31

5.3.2.2 Final radiated emission measurement (30 MHz to 1 GHz)

Ambient temperature	22 °C	Relative humidity	42 %

Position of EUT: The EUT was set-up on a turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied by a fully charged battery.

Test results: The test results from above 960 MHz and below 1 GHz were calculated with the following formula:

Result [dBµV/m] = reading [dBµV] + correction [dB] (cable loss antenna factor) + 6 dB (used attenuator) – 95.2 dB (according to 15.503 (k) [2])

The results of the standard subsequent measurement inside a semi anechoic chamber are indicated in the table below. The limits as well as the measured results (levels) refer to the above-mentioned standard while taking account of the specified requirements for a 3 m measuring distance.

The measurement time with the final detector is 1 second.

Result measured with the RMS detector above 960 MHz and below 1 GHz:

Frequency [MHz]	Result [dBm]	Limit [dBm]	Margin [dB]	Readings [dBµV]	Correction [dB]	Conversion from dBµV/m to dBm	Height [cm]	Azimuth [deg]	Pol.
962.975 *	-76.9	-75.3	1.6	-21.7	34.0	95.2	263	157	Hor.
Measurement uncertainty					±5.5 dB				

*: Highest peak (noise floor of the measuring system) with in the frequency range 960 MHz to 1 GHz.

Test: Passed

Test equipment used (refer clause 6):

1 - 10

5.3.2.3 Final radiated emission measurement (1 GHz to 40 GHz)

Ambient temperature	22 °C	Relative humidity	57 %

Position of EUT: The EUT was set-up on a turn device of a height of 1.5 m. The distance between EUT and antenna was 1 m (1 GHz to 26.5 GHz) and 0.3 m (26.5 GHz to 40 GHz).

Cable guide: For detail information of test set-up refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied by a fully charged battery.

Transmit on channel 1							
Frequency [MHz]	RMS average [dBm]	Limit [dBm]	Margin [dB]	Bandwidth * [kHz]	Pol.	Azimuth [deg]	Elevation [deg]
1996.799	-74.1	-51.3	22.8	1000	Hor.	181	30
3009.011	-71.3	-51.3	20.0	1000	Hor.	88	8
3633.890	-41.7	-41.3	0.4	1000	Hor.	88	6
4139.870	-52.2	-41.3	10.9	1000	Hor.	88	6
Transmit on channel 2							
Frequency [MHz]	RMS average [dBm]	Limit [dBm]	Margin [dB]	Bandwidth * [kHz]	Pol.	Azimuth [deg]	Elevation [deg]
1996.799	-74.1	-51.3	22.8	1000	Hor.	181	30
4055.990	-41.5	-41.3	0.2	1000	Hor.	89	8
Transmit on channel 3							
Frequency [MHz]	RMS average [dBm]	Limit [dBm]	Margin [dB]	Bandwidth * [kHz]	Pol.	Azimuth [deg]	Elevation [deg]
1996.799	-74.1	-51.3	22.8	1000	Hor.	181	30
4423.600	-42.0	-41.3	0.7	1000	Hor.	89	10
5027.120	-54.0	-41.3	12.9	1000	Hor.	89	10
Transmit on channel 4							
Frequency [MHz]	RMS average [dBm]	Limit [dBm]	Margin [dB]	Bandwidth * [kHz]	Pol.	Azimuth [deg]	Elevation [deg]
1996.799	-74.1	-51.3	22.8	1000	Hor.	181	30
4171.380	-45.3	-41.3	4.0	1000	Hor.	84	15
Measurement uncertainty				±4.7 dB			

*: The measuring receiver bandwidth

Test: Passed

Test equipment used (refer clause 6):

11 – 13, 15 – 19, 21 – 31

6 Test equipment and ancillaries used for tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. due
1	Semi anechoic chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
2	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
3	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
4	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
5	Positioner	TG1.5-10kg	Maturo	110/2648.01	483042	Calibration not necessary	
6	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
7	System software EMC32 M276	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
8	Ultralog Antenna	HL562E	Rohde & Schwarz	101079	482978	07.08.2019	08.2022
9	EMI Test receiver ESW	ESW44	Rohde & Schwarz	101828	482979	12.04.2019	04.2021
10	Cable C417	Sucoflex 118	Huber+Suhner	500654/118	-	Calibration not necessary	
11	Fully anechoic chamber M20	B83117-E2439-T232	Albatross Projects	103	480303	Calibration not necessary	
12	EMI Receiver / Spectrum Analyser	FSW43	Rohde & Schwarz	100586 & 100926	481720	04.03.2020	03.2022
13	Antenna (Horn)	3115	EMCO	9609-4918	480183	05.02.2018	02.2021
14	Antenna (Horn)	3115	EMCO	6761	480368	06.02.2020	02.2023
15	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
16	Swept CW generator	83650L	Agilent	3844A00554	480333	18.02.2020	02.2021
17	RF-cable No.3	Sucoflex 106B	Suhner	0563/6B	480670	Calibration not necessary	
18	RF-cable No.36	Sucoflex 106B	Suhner	0587/6B	480865	Calibration not necessary	
19	RF-cable 40	Sucoflex 106B	Suhner	0708/6B	481330	Calibration not necessary	
20	Standard gain horn antenna	14240-20	Flann	209388	481596	Calibration not necessary	
21	Standard gain horn antenna	16240-20	Flann	135671	480513	Calibration not necessary	
22	Standard gain horn antenna	18240-20	Flann	483	480294	Calibration not necessary	
23	Standard gain horn antenna	18240-20	Flann	482	480295	Calibration not necessary	
24	Standard gain horn antenna	20240-20	Flann	411	480297	Calibration not necessary	
25	Standard gain horn antenna	22240-20	Flann	469	480299	Calibration not necessary	
26	Preamplifier 100 MHz – 16 GHz	AFS6-00101600-23-10P-6-R	MITEQ	2011215	482333	13.02.2020	02.2022
27	Preamplifier 12 GHz - 18 GHz	JS3-12001800-16-5A	MITEQ	571667	480343	13.02.2020	02.2022
28	Preamplifier 18 GHz - 26 GHz	JS4-18002600-20-5A	MITEQ	658697	480342	13.02.2020	02.2022
29	Preamplifier 26 GHz - 40 GHz	JDM2-26004000-25-10P	MITEQ	128746	482806	17.02.2020	02.2022

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. due
30	RF-cable 1 m	Insulated Wire Inc.	Insulated Wire	KPS-1533-400-KPS	480300	Calibration not necessary	
31	RF-cable 2m	Insulated Wire Inc.	Insulated Wire	KPS-1533-800-KPS	480302	Calibration not necessary	

7 Test site Validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA	ANSI C63.4-2014	19.09.2019	18.09.2021
Fully anechoic chamber M20	480303	1 -18 GHz	SVSWR	CISPR 16-1-4 Amd. 1	13.07.2018	12.07.2021

8 Report history

Report Number	Date	Comment
F191168E2	07.07.2020	Document created

9 List of annexes

Annex A Test setup photos 6 pages