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Test Report

Report Number:

F191757E1

Equipment under Test (EUT):

SenseGateway-ExR-(DMS)

Applicant:

Savvy Telematic Systems AG

Manufacturer:

Savvy Telematic Systems AG

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] **RSS-247 Issue 2 (February 2017)**, Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

[4] **RSS-Gen Issue 5 Amendment 1 (March 2019)**, General Requirements for Compliance of Radio Apparatus

[5] **558074 D01 15.247 Meas Guidance v05r02 (April 2019),** GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES

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	Paul NEUFELD		09.01.2020
	Name	Signature	Date
Reviewed and approved by:	Bernd STEINER		09.01.2020
	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 generalizations 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.

Contents: Page

1 Identification

1.1 Applicant

Name:	Savvy Telematic Systems AG
Address:	Grabenstr. 9, 8200 Schaffhausen
Country:	Switzerland
Name for contact purposes:	Mr. André SCHÄR
Phone:	+41-52-63346-00
eMail Address:	andre.schaer@savvy-telematics.com
Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	Savvy Telematic Systems AG
Address:	Grabenstr. 9, 8200 Schaffhausen
Country:	Switzerland
Name for contact purposes:	Mr. André SCHÄR
Phone:	+41-52-63346-00
eMail Address:	andre.schaer@savvy-telematics.com
Applicant represented during the test by the following person:	-

1.3 Test Laboratory

The tests were carried out by:

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-17186-01-02 and D-PL-17186-01-05, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment under Test)

EUT	
Test object: *	Autonomous Telematic Device
PMN / Model name: *	SenseGateway-ExR-(DMS)
FCC ID: *	2ATWF-SGWEXRDMS
ISED Certification number: * IC: *	25039-SGWEXRDMS
HVIN: *	1062
HMN: *	n/a
FVIN: *	1.0.20-201909231411
Serial number: *	1062-000726
PCB identifier: *	V1.2
Hardware version: *	V1.0
Software version: *	1.0.20

* Declared by the applicant

IEEE 802.15.4 (2.4GHz) frequencies				
Channel 11	RX	2405 MHz	TX	2405 MHz
Channel 19	RX	2440 MHz	TX	2440 MHz
Channel 25	RX	2475 MHz	TX	2475 MHz

Equipment used for testing	
Control-Terminal*1	SenseGateway-ExR-(DMS) with USB cable attached (SN: 1062-000802)
Laptop PC:*2	Fujitsu Lifebook S751 (PM No. 201036)

*1 Provided by the applicant
*2 Provided by the laboratory

1.5 Technical Data of Equipment

IEEE 802.15.4 radio mode						
Fulfils radio specification: *	IEEE 802.15.4					
Radio chip:	ATmega128RFA1					
Antenna type: *	Embedded ceramic					
Antenna name: *	Wuerth Chip-Antenna WE-MCA					
Antenna gain: *	Max 0.5 dBi					
Antenna connector: *	n/a					
Power supply EUT: *	DC (by internal batteries)					
Supply voltage EUT: *	U_{nom} =	3.6 V DC	U_{min} =	3.0 V DC	U_{max} =	3.7 V DC
Supply voltage radio module: *	U_{nom} =	3.3 V DC	U_{min} =	3.23 V DC	U_{max} =	3.39 V DC
Type of modulation: *	O-QPSK (250 kbit/s)					
Operating frequency range: *	2405 – 2475 MHz					
Number of channels: *	15 (5 MHz channel spacing)					
Temperature range: *	-40 °C to +85 °C					
Lowest / highest internal clock frequency: *	32.768 kHz to 2475 MHz					

* Declared by the applicant

1.6 Dates

Date of receipt of test sample:	29.10.2019
Start of test:	30.10.2019
End of test:	21.11.2019

2 Operational States

The EUT is the radio part of an autonomous telematics system.
The EUT has a build in IEEE 802.15.4 transceiver. Up to 4 sensors can be connected to the EUT, which sends the data periodically to a gateway device.

The EUT:

2.1 The following states were defined as the operating conditions

The DUT was supplied via internal batteries; no cables were connected to the EUT.

During the test, a second device (ancillary) was outside the anechoic chamber.

2.1.1 Radio tests

The control terminal is a second “SenseGateway-ExR-(DMS)” that was communicating via IEEE 802.15.4 radio link with the EUT. The connection with the control terminal could be established by following settings:

A connection to the control terminal was established via USB cable.

The USB connection was converted to a serial connection on the EUT.
The following COM port settings were used with “tera term”.

Baud rate:	115200
Data:	8 bit
Parity:	None
Stop:	1 bit
Flow control:	None

The tests were performed using the following setting for the EUT: phy5f06.

With this setting, only embedded antenna was active during the tests. Also the power setting was set to -16.5 dBm.

All relevant RF parameter were set using the control-terminal as described above. The parameters were set according to the documentation as provided by the applicant (EMV_Prüfanleitung_SAVVY_SenseGateway-ExR-(DMS))

2.1.2 Operation Modes

Operation Mode	Channel	Frequency [MHz]	Data rate	Power setting [dBm]
1	11	2405	250 kbit/s	-16.5
2	18	2440	250 kbit/s	-16.5
3	25*	2475	250 kbit/s	-16.5

* Remark: As declared by the applicant channel 26 is disabled by software and therefore this will not be used by the device

3 Additional Information

The tested EUT was not labeled with the final label.

All tests were performed using an unmodified sample.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [3] or RSS-Gen, Issue 5 [4]	Status	Refer page
DTS Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (a) [3]	Passed	12 et seq.
Maximum conducted (average) output power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [3]	Passed*1	16 et seq.
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [3]	Passed	18 et seq.
Average Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [3]	Passed	18 et seq.
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3] 8.9 [4], 8.10 [4]	Passed	20 et seq.
Radiated emissions (transmitter)	0.009 – 26,500	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3] 8.9 [4], 8.10 [4]	Passed	24 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Not applicable*2	---

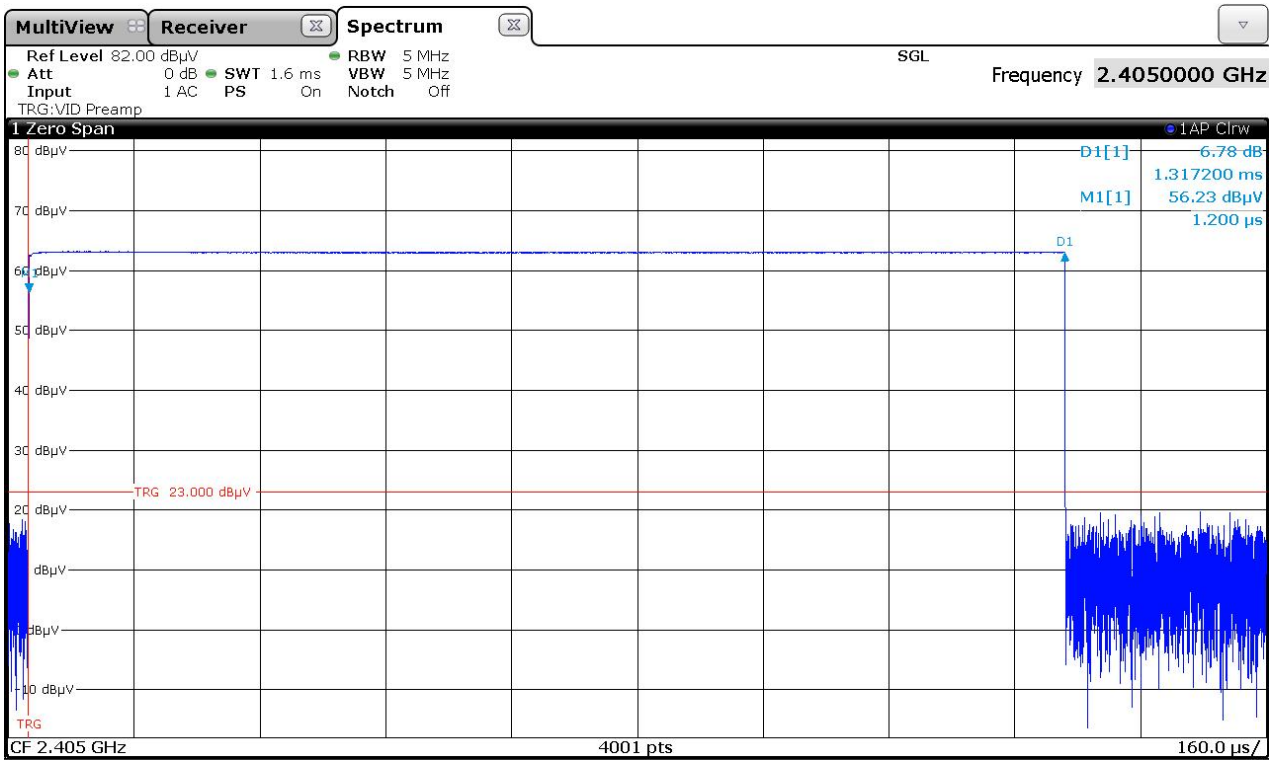
*1 Antenna gain does not exceed 6 dBi, no power reduction necessary
*2 EUT is battery supplied only, without any possibility of charging

5 Results

5.1 Duty cycle

The duty cycle of the EUT was not constant, as required by the procedures in [1] and [5]. Therefore, the procedures for non-constant duty cycle were used in the following test report and no duty cycle measurement was performed.

For the measurement procedures the TX-on time t is required. The following plot shows the measurement result for obtaining t. Since no procedure is submitted for this measurement, the settings for duty cycle 11.6 in [1] were used for the measurement. The time T for the following report will be calculated as 1.317 ms.



Test equipment (please refer to chapter 6 for details)
2 - 11

5.2 DTS Bandwidth / 99% Bandwidth

5.2.1 Method of measurement (radiated)

The EUT was tested in an anechoic chamber, with a setup and procedure as described in 5.6.1.

DTS bandwidth:

The measurement procedure refers to part 11.8.1 of document [1].

- Set RBW = 100 kHz.
- Set the video bandwidth (VBW) ≥ 3 x RBW.
- Detector = Peak.
- Trace mode = max hold.
- Sweep = auto couple.
- Allow the trace to stabilize.
- 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 following procedure was used for measuring the 99 % bandwidth:

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:

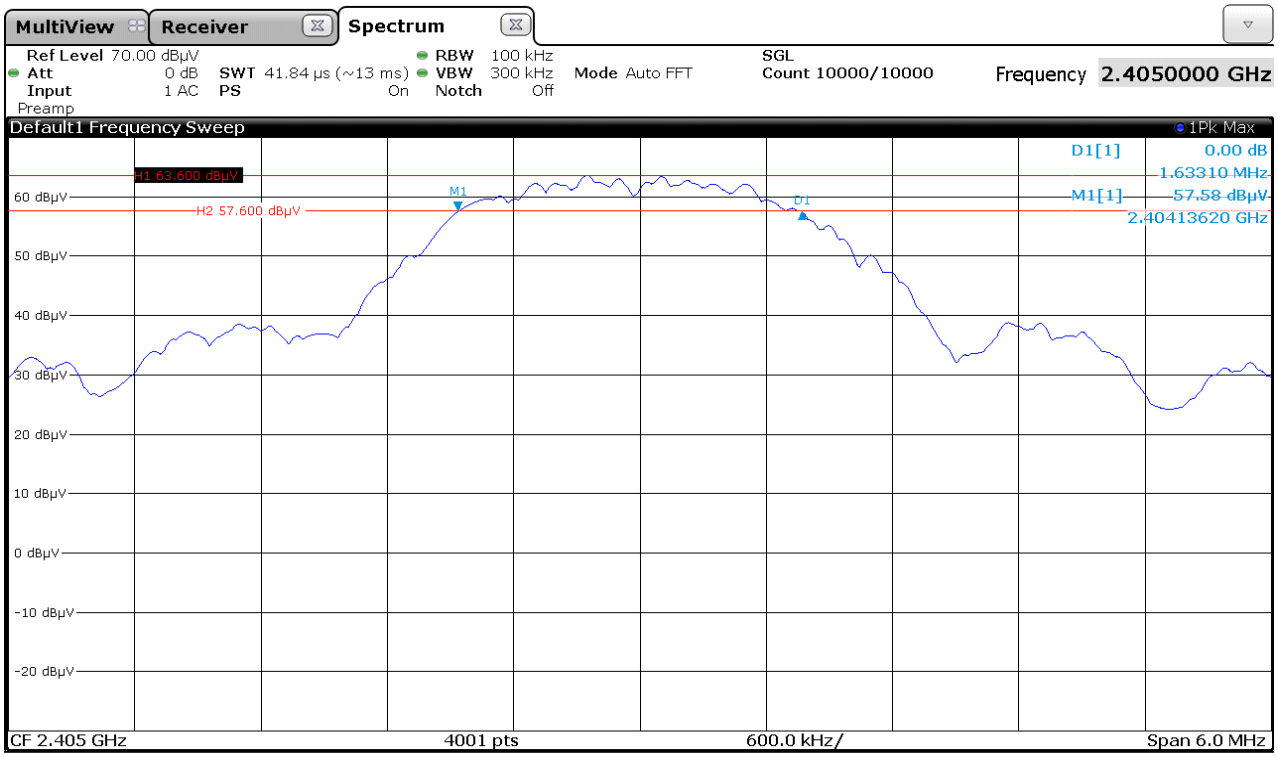
- The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
- The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.
- 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.
- 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.
- 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 maybe reported in addition to the plot(s).

5.2.2 Test results (radiated)

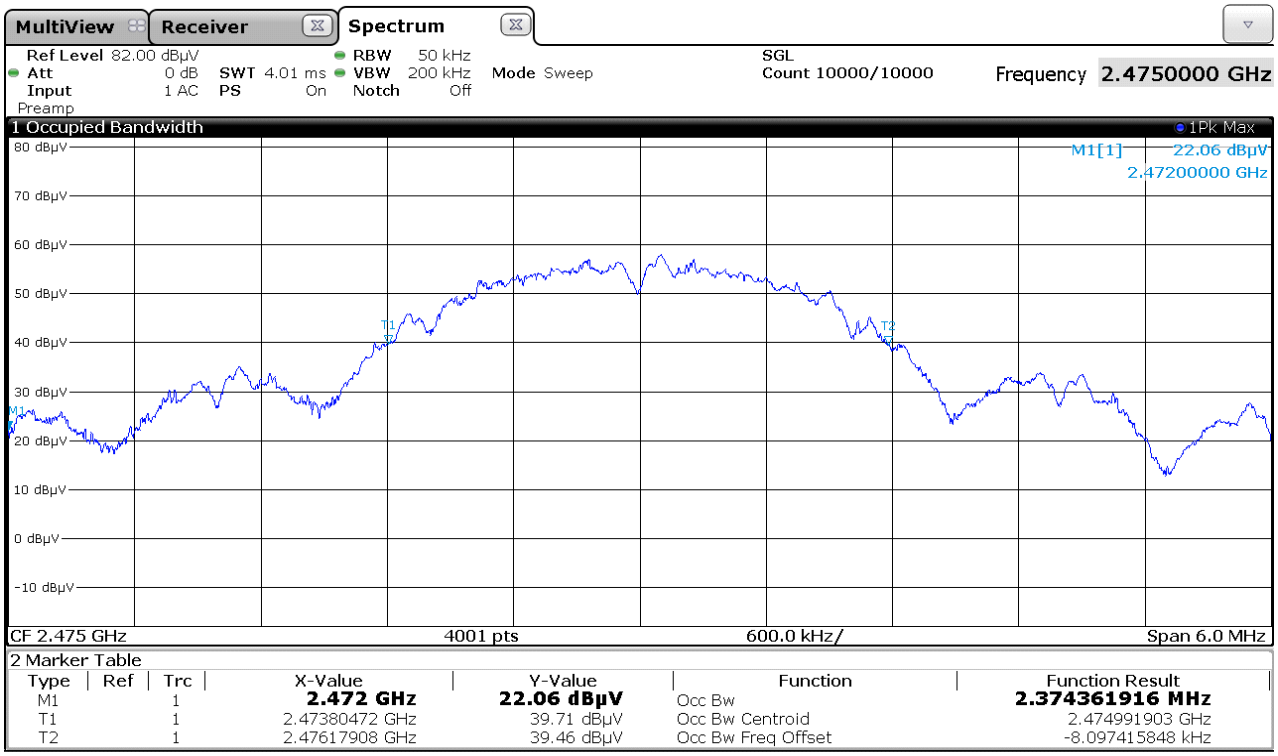
Ambient temperature	22 °C
Relative humidity	32 %

Date	18.11.2019
Tested by	P. NEUFELD

DTS bandwidth (Operation mode 1):



99% bandwidth (Operation mode 3):



OP mode	Data rate	Center Frequency [MHz]	Minimum 6 dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
1	250 kbit/s	2405	0.5	1.6331	2.2983	Passed
2	250 kbit/s	2440	0.5	1.6691	2.3318	Passed
3	250 kbit/s	2475	0.5	1.6511	2.3744	Passed

Test equipment (please refer to chapter 6 for details)
2 - 11

5.3 Maximum output power

5.3.1 Method of measurement (radiated)

The EUT was tested in an anechoic chamber, with a setup and procedure as described in 5.6.1.

Acceptable measurement configurations

Procedure 11.9.2.2.6 in [1] was used for the following test.

Method AVGSA-3 uses rms detection across ON and OFF times of the EUT with max hold. The procedure for this method is as follows:

- Set span to at least 1.5 times the OBW.
- Set sweep trigger to “free run.”
- Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.
- Set VBW ≥ [3 × RBW].
- Number of points in sweep ≥ [2 × span / RBW]. (This gives bin-to-bin spacing ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)
- Sweep time ≤ (number of points in sweep) × T, where T is defined in 11.6. [1] If this gives a sweep time less than the auto sweep time of the instrument, then method AVGSA-3 shall not be used (use AVGSA-3A). The purpose of this step is so that the averaging time in each bin is less than or equal to the minimum time of a transmission.
- Detector = RMS (power averaging).
- Trace mode = max hold.
- Allow max hold to run for at least 60 s or longer as needed to allow the trace to stabilize. Compute power by integrating the spectrum across the OBW of the signal using the instrument’s band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW.

The measurement was performed at the upper and lower end and the middle of the assigned frequency band.

The formula in 11.12.2.2 e) in [1] was used to calculate the EIRP power:

$E = EIRP - 20\log(d) + 104.8$
$EIRP = E - 95.3$

$MOP = EIRP - G$

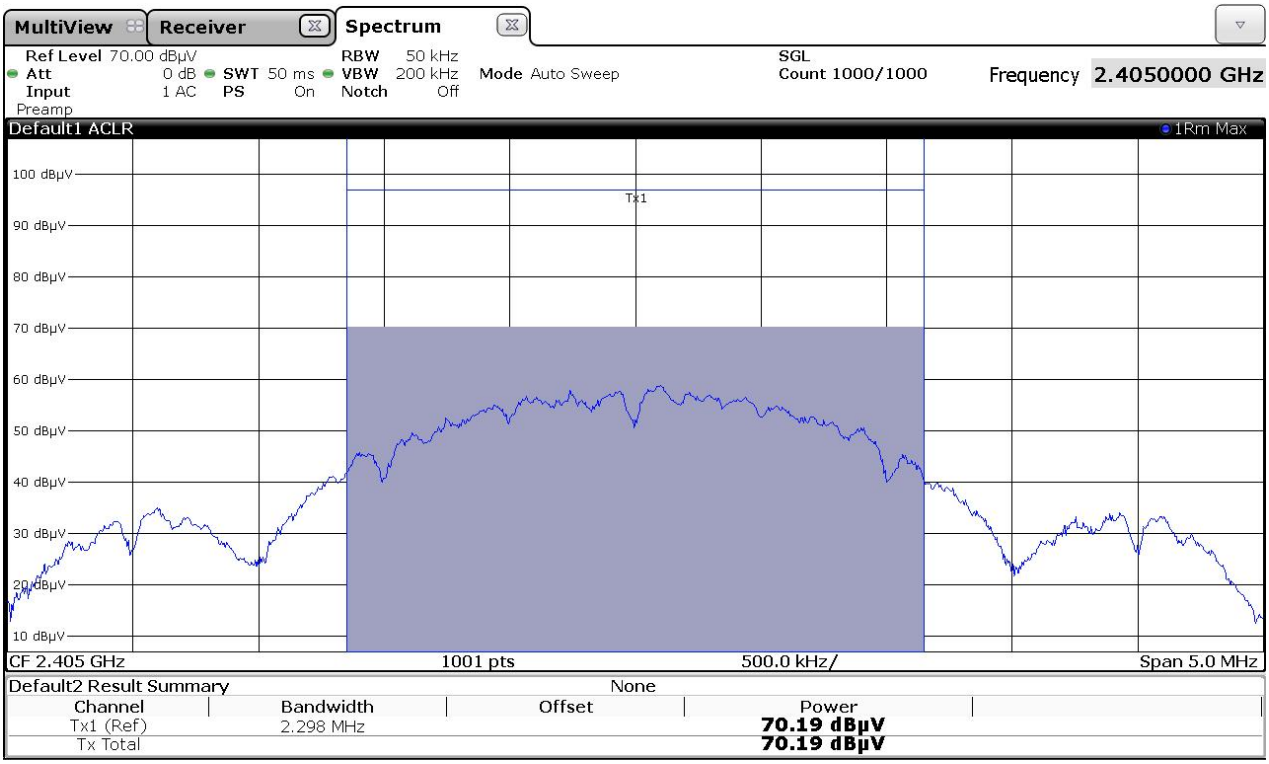
E	is the electric field strength in dBµV/m
EIRP	is the equivalent isotropically radiated power in dBm
d	is the specified measurement distance in m
G	is the antenna gain in dBi
MOP	is the maximum output power – measured antenna port conducted – in dBm

5.3.2 Test results (radiated)

Ambient temperature	22 °C
Relative humidity	32 %

Date	18.11.2019
Tested by	P. NEUFELD

Maximum output power (MOP) (Operation mode 1):



The antenna gain is below 6 dBi, therefore no conducted output limit reduction is necessary.

Operation mode		Frequency [MHz]	Reading [dBµV]	Corr. Fact. [dB/m]	Corr. Reading [dBµV/m]	EIRP [dBm]	MOP [dBm]	Limit [dBm]
1	250 kbit/s	2405	70.19	33.6	103.79	8.49	7.99	30
2	250 kbit/s	2440	68.47	33.7	102.17	6.87	6.37	30
3	250 kbit/s	2475	65.90	33.8	99.70	4.40	3.90	30

MOP: Maximum (average) output power conducted

Test equipment (please refer to chapter 6 for details)
2 - 11

5.4 Average Power Spectral Density

5.4.1 Method of measurement (radiated)

The EUT was tested in an anechoic chamber, with a setup and procedure as described in 5.6.1.

The measurement procedure refers to part 11.10.7 of document [1].

Method AVGPSD-3 uses rms detection across ON and OFF times of the EUT with max hold.

The following procedure is applicable when the EUT cannot be configured to transmit continuously (i.e., D < 98%), when sweep triggering/signal gating cannot be used to measure only when the EUT is transmitting at its maximum power control level, and when the transmission duty cycle is not constant (i.e., duty cycle variations exceed ±2%):

- Set the instrument span to a minimum of 1.5 times the OBW.
- Set sweep trigger to “free run.”
- Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
- Set VBW ≥ [3 × RBW].
- Number of points in sweep ≥ [2 × span / RBW]. (This ensures that bin-to-bin spacing is ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)
- Sweep time ≤ (number of points in sweep) × T, where T is defined in 11.6. [1]
    - NOTE—If this results in a sweep time less than the auto sweep time of the instrument, then this method shall not be used (use AVGPSD-2A instead). The purpose of this step is to ensure that averaging time in each bin is less than or equal to the minimum time of a transmission.
- Detector = RMS (power averaging).
- Trace mode = max hold.
- Allow max hold to run for at least 60 s or longer as needed to allow the trace to stabilize.
- Use the peak marker function to determine the maximum PSD level.
- If the measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

The formula in 11.12.2.2 e) in [1] was used to calculate the EIRP power:

$E = EIRP - 20\log(d) + 104.8$
$EIRP = E - 95.3$

$MOP = EIRP - G$

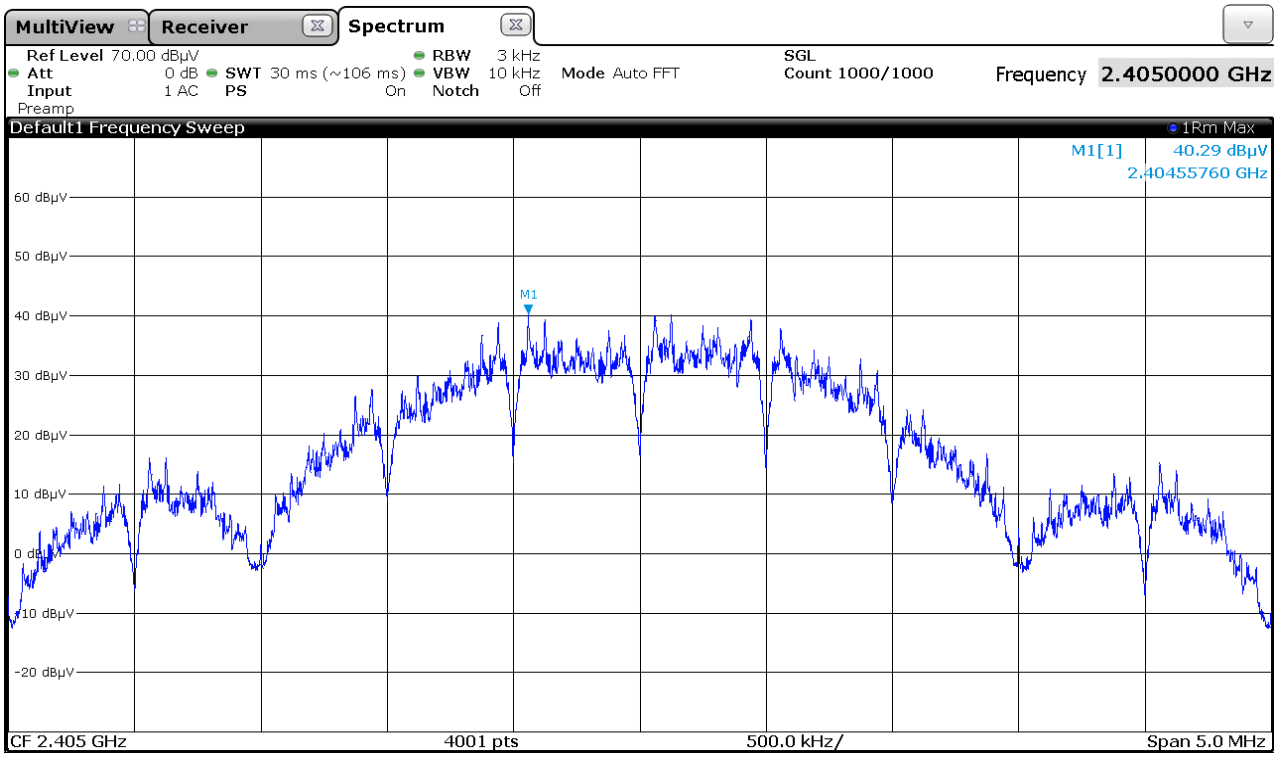
E	is the electric field strength in dBµV/m
EIRP	is the equivalent isotropically radiated power in dBm
d	is the specified measurement distance in m
G	is the antenna gain in dBi
MOP	is the maximum output power – measured antenna port conducted – in dBm

5.4.2 Test results (radiated)

Ambient temperature	22 °C
Relative humidity	32 %

Date	18.11.2019
Tested by	P. NEUFELD

Power Spectral Densitiy (PSD) (Operation mode 1):



Operation mode		Frequency [MHz]	Reading [dBµV]	Corr. Fact. [dB/m]	Corr. Reading [dBµV/m]	EIRP [dBm/3kHz]	PSD [dBm/3 kHz]	Limit [dBm]
1	250 kbit/s	2405	40.29	33.6	73.89	-21.41	-21.91	8
2	250 kbit/s	2440	38.28	33.7	71.98	-23.32	-23.82	8
3	250 kbit/s	2475	36.17	33.8	69.97	-25.33	-25.83	8

Test equipment (please refer to chapter 6 for details)
2 - 11

5.5 Band-edge compliance

5.5.1 Method of measurement (band edges next to unrestricted bands (radiated))

The EUT was tested in an anechoic chamber, with a setup and procedure as described in 5.6.1.

The relating measurements were carried out in a conducting manner. Therefore, the antenna connector was directly connected to a spectrum analyzer. The measurement procedure refers to part 11.11.2 and 11.11.3 of document [1].

Measurement Procedure Reference – Reference Level:

- Set the span to ≥ 1.5 times the DTS Bandwidth.
- RBW = 100 kHz.
- VBW ≥ 300 kHz.
- Detector = Peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level.

Measurement Procedure – Unwanted Emissions

- Set the center frequency and span to encompass the frequency range to be measured.
- RBW = 100 kHz.
- VBW ≥ 300 kHz.
- Detector = Peak.
- Ensure that the number of measurement points ≥ span/RBW.
- Sweep time = auto couple.
- Trace Mode = max hold.
- Allow the trace to stabilize.
- Use the peak marker function to determine the maximum amplitude level.

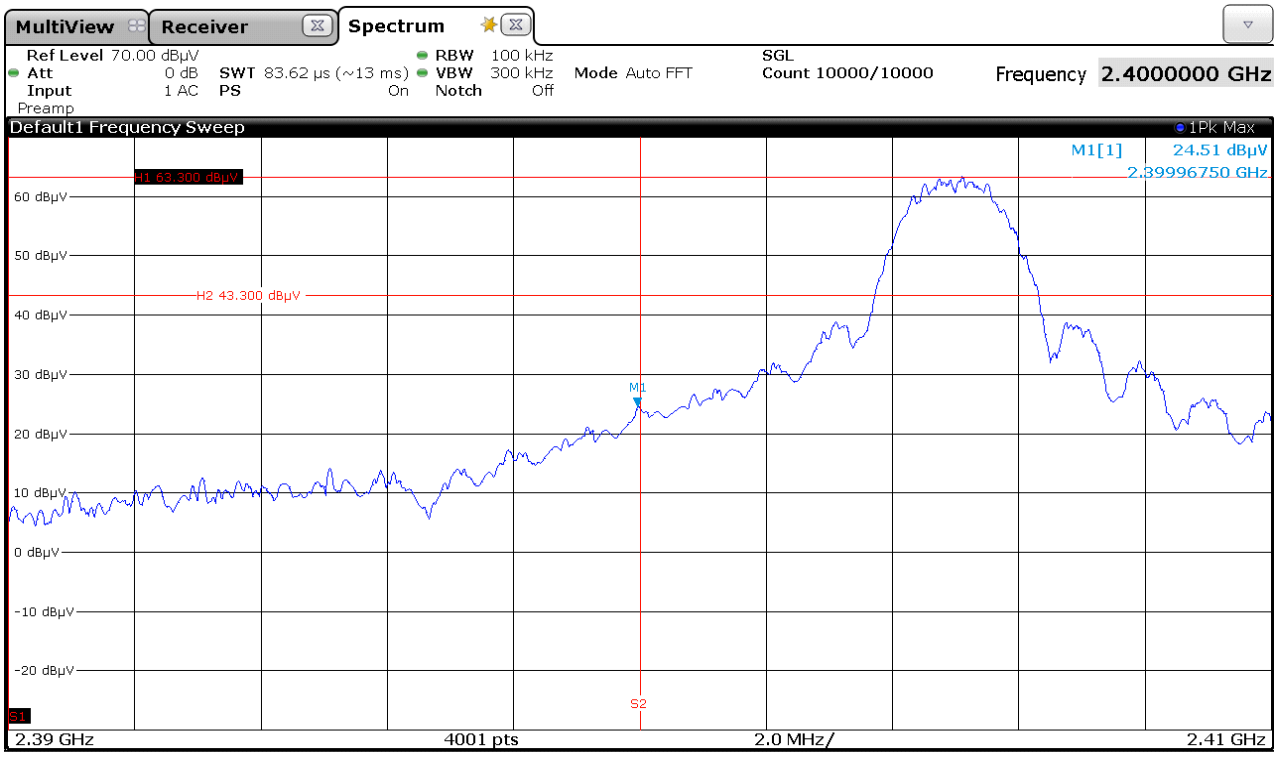
The measurement procedure at the band edges was simplified by performing the measurement in just one plot. Both, the in-band-emission and the unwanted emission were be encompassed by the span. After trace stabilization, the maximum peak was be determined by a peak detector and the value was marked by an appropriate limit line. The second limit line, which is 20 dB below the first, marks the limit for the emissions in the unrestricted band. A maximum-peak-detector marks the highest emission in the unrestricted band next to the band edge.

5.5.2 Test results (radiated)

Ambient temperature	22 °C
Relative humidity	32 %

Date	18.11.2019
Tested by	P. NEUFELD

Unrestricted band edge (Operation mode 1):



Operation mode	Data rate	Frequency [MHz]	Reference Level [dBµV]	Limit [dBµV]	Emission Level [dBµV]	Margin [dB]	Result
1	250 kbit/s	2399.9675	63.3	43.3	24.5	18.8	Passed

Test equipment (please refer to chapter 6 for details)
2 - 11

5.5.3 Method of measurement (band edges next to restricted bands (radiated))

Acceptable measurement configurations

The same measurement configuration as described in 5.6.1 was used for the preview and final measurement of the peak values.

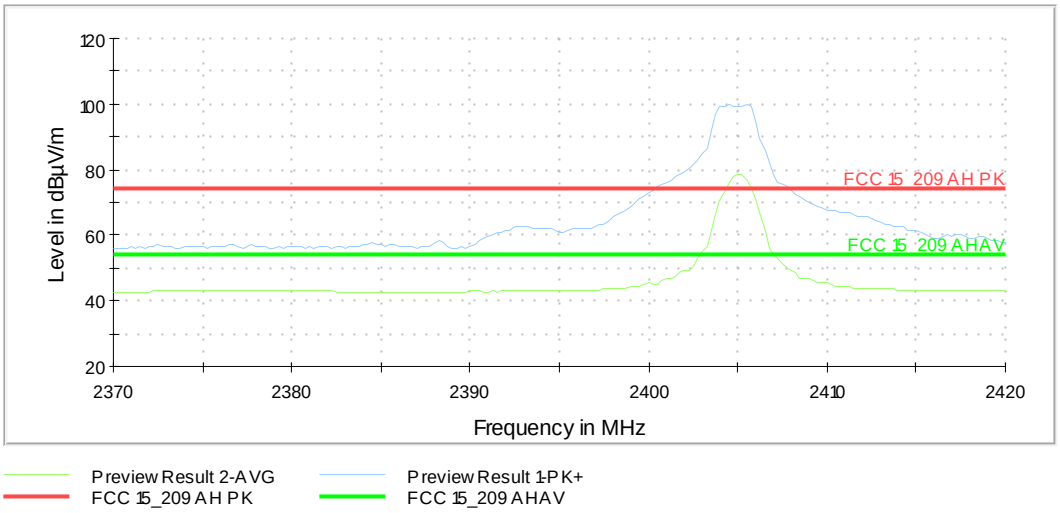
The average value was determined by using method 11.12.2.5.3 of document [1]

5.5.4 Test results (radiated)

Ambient temperature	22 °C
Relative humidity	40 %

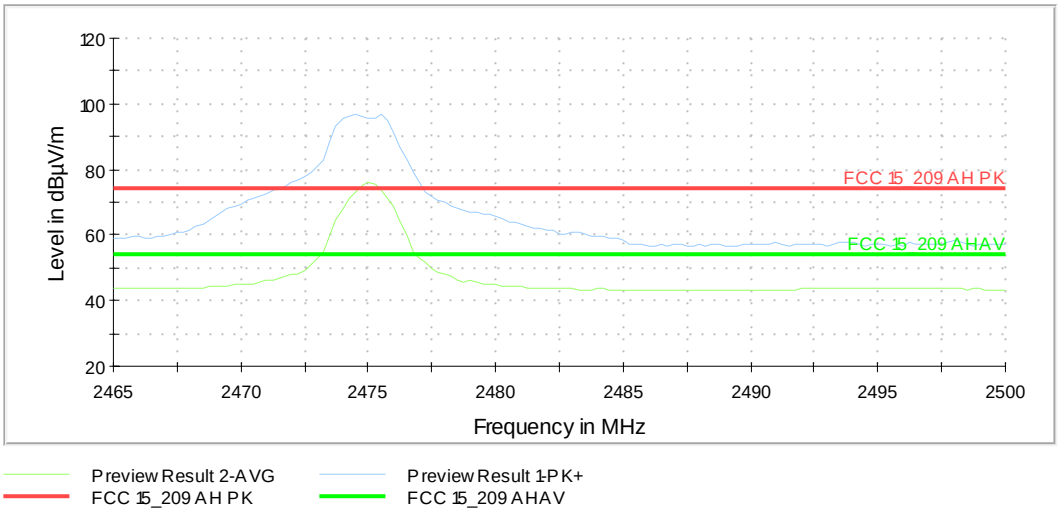
Date	18.11.2019
Tested by	P. NEUFELD

Restricted band edge (Operation mode 1):



Lower band edge									
Operation mode 1			Duty cycle correction factor was not applied for the Average reading due to measurement method						
Frequency	Max Peak	Average	Limit	Margin	Pol	Azimuth	Elevation	Correction	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dBµV/m]	dB		[°]	[°]	[dB]	
2388.250	55.38	---	74.00	18.62	V	213.0	60.0	33.3	Passed
2390.000	---	31.46	54.00	22.54	H	238.0	90.0	33.3	Passed
Measurement uncertainty			+2.2 dB / -3.6 dB						

Restricted band edge (Operation mode 3):



Upper band edge									
Operation mode 3			Duty cycle correction factor was not applied for the Average reading due to measurement method						
Frequency	Max Peak	Average	Limit	Margin	Pol	Azimuth	Elevation	Correction	Result
[MHz]	[dBµV/m]	[dBµV/m]	[dBµV/m]	dB		[°]	[°]	[dB]	
2475.000	---	36.73	54.00	17.27	H	241.0	90.0	33.5	Passed
2475.000	64.20	---	74.00	9.80	H	241.0	90.0	33.5	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB					

Test equipment (please refer to chapter 6 for details)
2 – 11, 13

5.6 Maximum unwanted emissions

5.6.1 Method of measurement (radiated emissions)

The radiated emission measurement is subdivided into five stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 9 kHz to 1 GHz.
- A preliminary and final measurement carried out in a semi anechoic chamber with a varying antenna height in the frequency range 30 MHz to 1 GHz.
- A preliminary measurement carried out in a fully anechoic chamber with a variable 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.

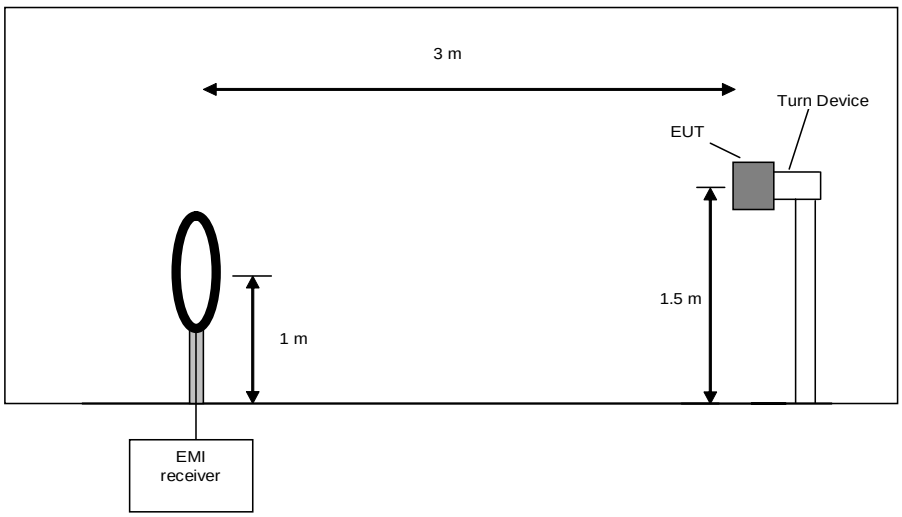
Preliminary measurement (9 kHz to 30 MHz):

In the first stage a preliminary measurement will be performed in a shielded room with a measuring distance of 3 meters. Table top devices will set up on a non-conducting turn device on the height of 1.5m. Floor-standing devices will be placed directly on the turntable/ground plane. The set-up of the Equipment under test will be in accordance to [1].

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 found 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	200 Hz
150 kHz to 30 MHz	10 kHz

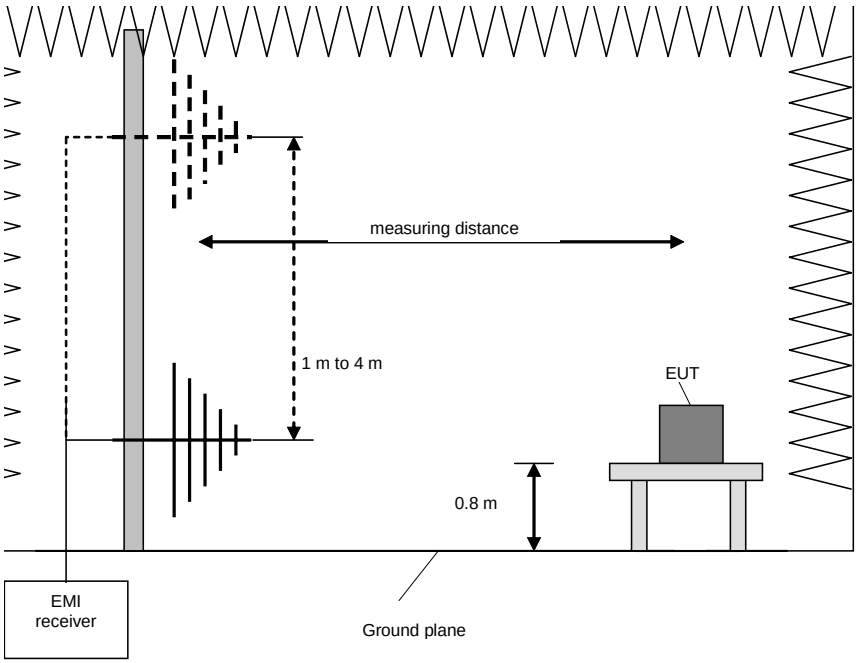


Preliminary and final measurement (30 MHz to 1 GHz)

The preliminary and final measurements were conducted in a semi-anechoic chamber with a metal ground plane. During the test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarization and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

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

Test	Frequency range	Resolution bandwidth
Preliminary measurement	30 MHz to 1 GHz	100 kHz
Frequency peak search	+ / - 1 MHz	10 kHz
Final measurement	30 MHz to 1 GHz	120 kHz



Procedure preliminary measurement:

The following procedure is used:

1. Set the measurement antenna to 1 m height.
2. Monitor the frequency range at vertical polarisation and a EUT azimuth of 0 °.
3. Rotate the EUT by 360° to maximize the detected signals.
4. Repeat 1) to 2) with the horizontal polarisation 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.
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 +/- 30° 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.

Preliminary and final measurement (1 GHz to 40 GHz)

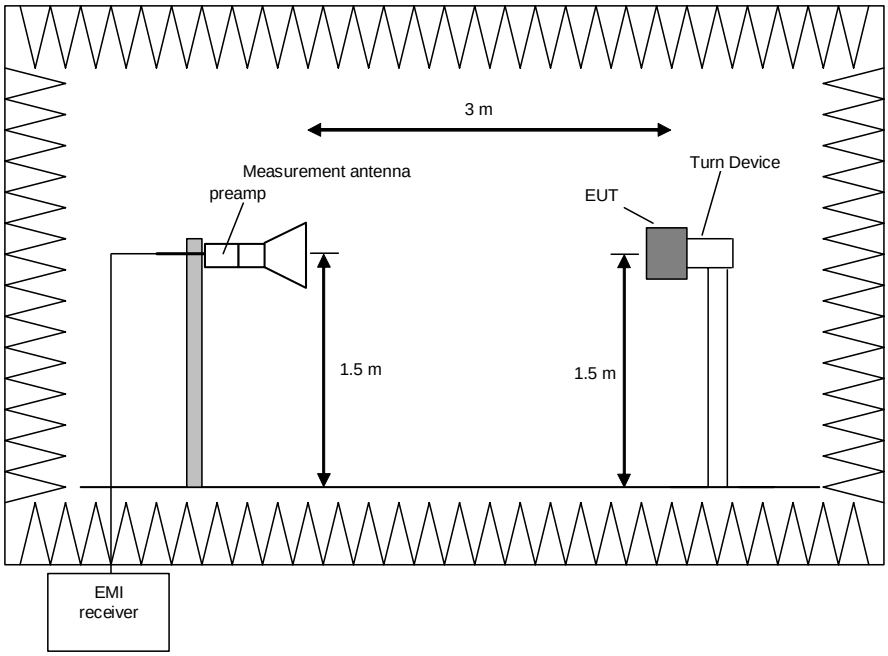
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

Preliminary measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The spectrum analyser set to MAX Hold mode and a resolution bandwidth of 100 kHz. 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 25 / 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz



Procedure preliminary measurement:

Pre scans were performed in the frequency range 1 to 40 GHz.
The following procedure will be used:

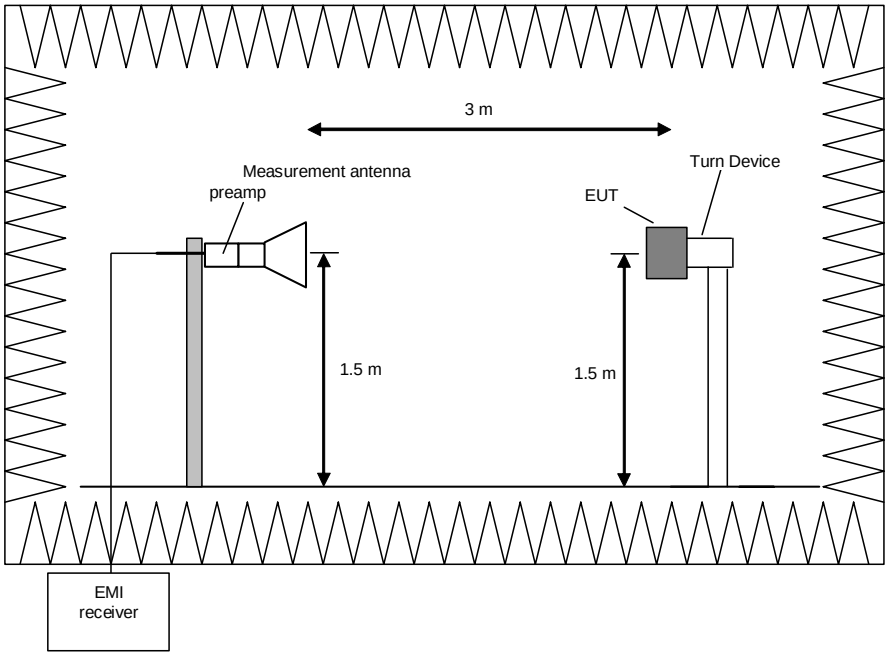
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an 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.

Final measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. The measurement will be performed by rotating the turntable through 0 to 360° in the worst-case EUT orientation which was obtained during the preliminary measurements.

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 25 / 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz



Procedure of measurement:

The measurements were performed in the frequency ranges 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 25 /26.5 GHz and 26.5 GHz to 40 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 average detector activated.
4) Rotate the turntable from 0° to 360° to find the TT Pos. 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.

5.6.2 Test results (radiated emissions) – Emissions from 9 kHz – 26.5 GHz

5.6.2.1 Preliminary radiated emission measurement 9 kHz – 26.5 GHz

Ambient temperature	22 °C	Date	18.11.2019 20.11.2019 21.11.2019
Relative humidity	59 %	Tested by	P. NEUFELD

Position of EUT: For tests from 30 MHz to 1 GHz the EUT was placed on a table with the height of 0.8 m. The distance between EUT and antenna was 3 m.

For tests for f > 1 GHz and for f < 30 MHz, the EUT was set-up on an EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.

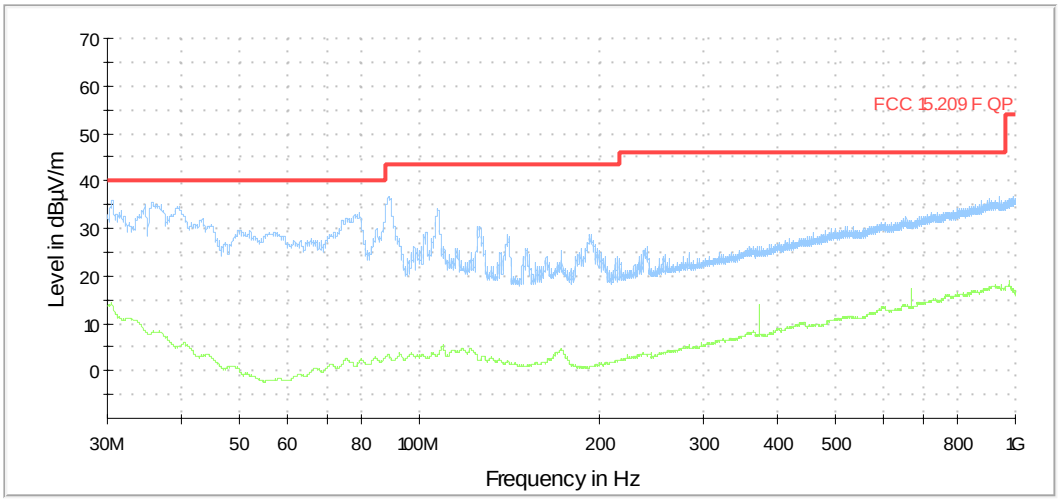
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: Only the plot of the worst case emission is submitted below.

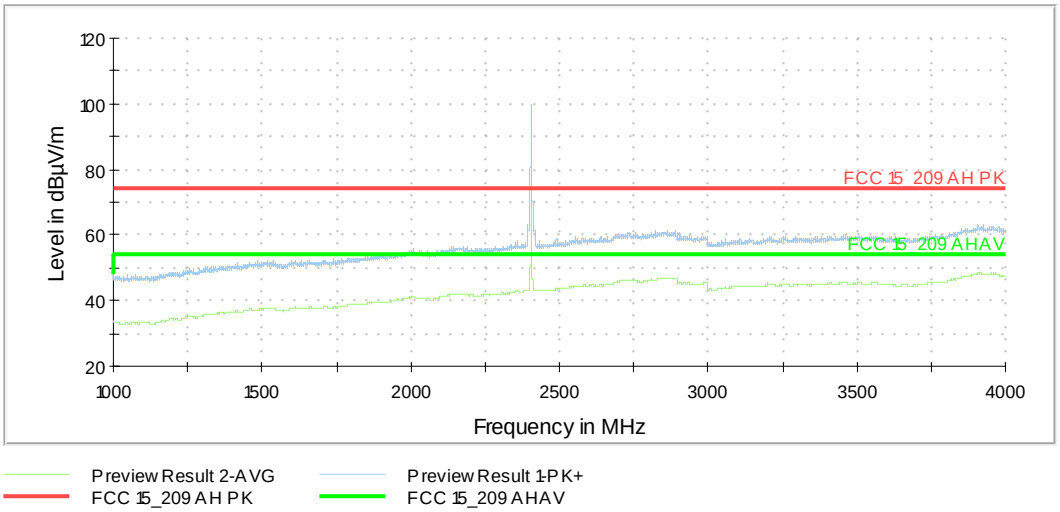
Remark: No Emissions greater than 20 dB to the limit was found below 30 MHz during the preliminary test, therefore no final test was performed, and no results submitted.

Plots of the worst case transmitter spurious emissions

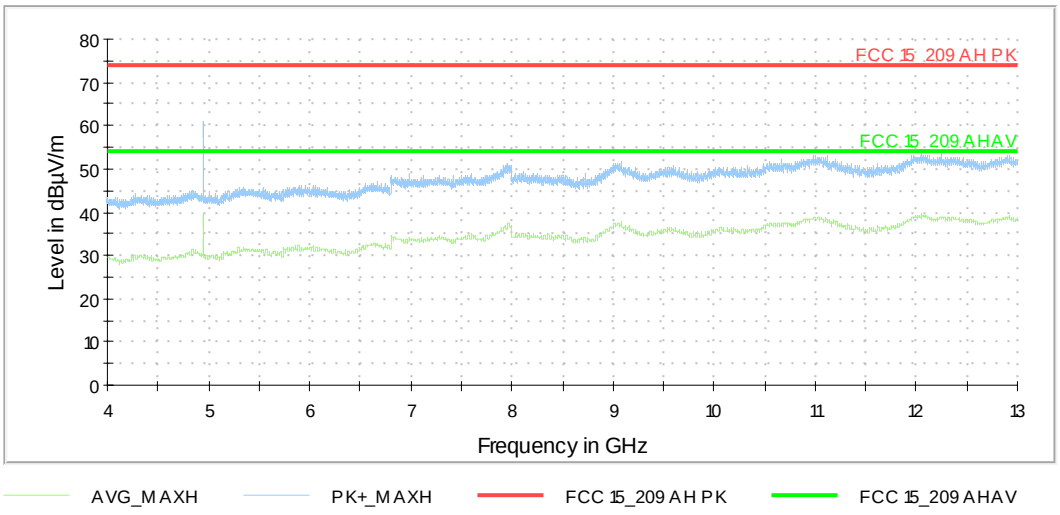
191757_Ch25_30M-1G: Spurious emissions from 30 MHz to 1 GHz (operation mode 3): Preliminary plot



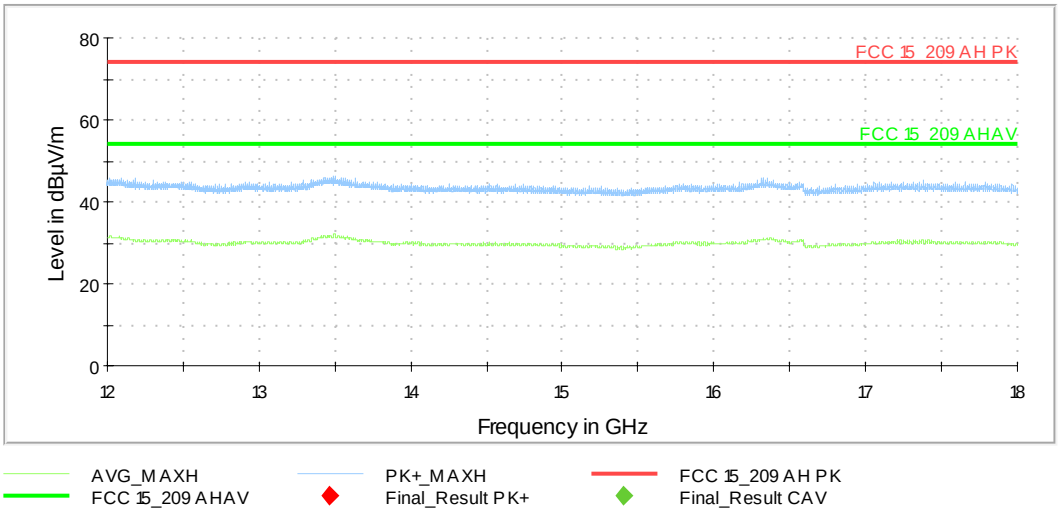
191757_ch11_1-4G_phy5f06: Spurious emissions from 1 GHz to 4 GHz (operation mode 1): Preliminary plot



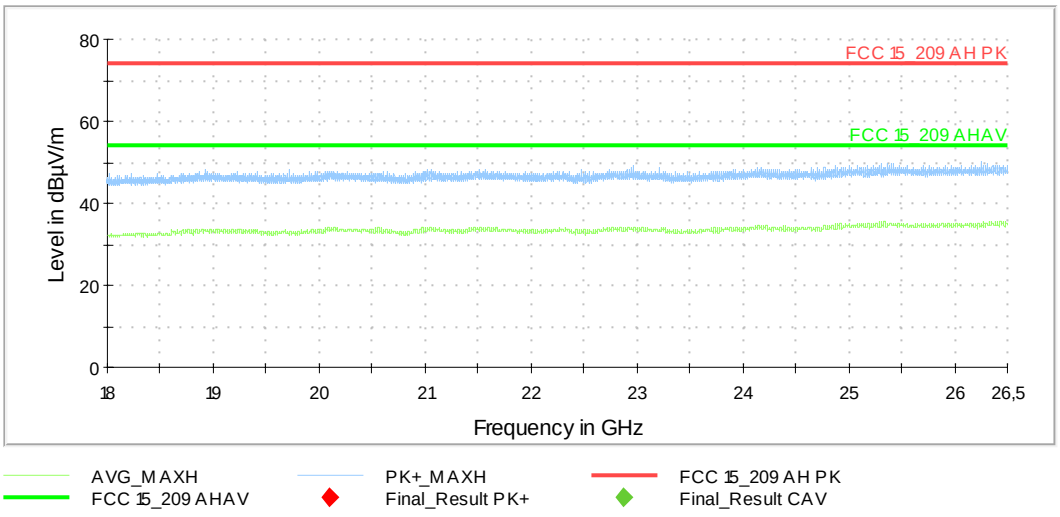
191757_ch25_4-12G_phy5f06: Spurious emissions from 4 GHz to 12 GHz (operation mode 2): Preliminary plot



191757_ch25_12-18G_phy5f06: Spurious emissions from 12 GHz to 18 GHz (operation mode 3):
Preliminary plot - no final measurement conducted



191757_ch25_12-18G_phy5f06: Spurious emissions from 18 GHz to 26.5 GHz (operation mode 3):
Preliminary plot - no final measurement conducted



5.6.2.2 Final radiated measurements

Transmitter operates at the lower end of the assigned frequency band (operation mode 1)

Frequency [MHz]	QuasiPeak [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Meas. Time [ms]	Bandwidth [kHz]	Height [cm]	Pol	Azimuth [deg]	Corr. [dB]
34.260000	17.11	40.00	22.89	1000.0	120.000	124.0	V	299.0	23.1
34.590000	16.50	40.00	23.50	1000.0	120.000	122.0	V	209.0	22.9
35.620000	15.66	40.00	24.34	1000.0	120.000	115.0	V	355.0	22.4
35.630000	15.82	40.00	24.18	1000.0	120.000	150.0	V	11.0	22.4
88.930000	9.72	43.50	33.78	1000.0	120.000	391.0	H	73.0	16.5
107.310000	10.03	43.50	33.48	1000.0	120.000	180.0	V	32.0	17.2
Measurement uncertainty					+2.2 dB / -3.6 dB				

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
2404.500	100.44	---	Fund.	-	H	231.0	90.0	33.4
2404.500	---	75.22	Fund.	-	H	231.0	90.0	33.4
4811.000	---	49.90	54.00	4.60	V	285.0	90.0	-1.9
4811.000	57.60	---	74.00	16.40	V	285.0	90.0	-1.9
Measurement uncertainty				+2.2 dB / -3.6 dB				

Transmitter operates at the middle of the assigned frequency band (operation mode 2)

Frequency [MHz]	QuasiPeak [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Meas. Time [ms]	Bandwidth [kHz]	Height [cm]	Pol	Azimuth [deg]	Corr. [dB]
34.220000	17.03	40.00	22.97	1000.0	120.000	134.0	V	120.0	23.2
79.080000	9.03	40.00	30.97	1000.0	120.000	131.0	V	159.0	15.8
79.510000	9.39	40.00	30.61	1000.0	120.000	150.0	V	181.0	15.9
88.040000	10.44	43.50	33.06	1000.0	120.000	110.0	V	169.0	16.5
88.530000	10.48	43.50	33.02	1000.0	120.000	150.0	V	158.0	16.5
107.310000	10.23	43.50	33.27	1000.0	120.000	100.0	V	179.0	17.2
Measurement uncertainty					+2.2 dB / -3.6 dB				

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
2439.500	---	73.43	Fund.	-	H	231.0	90.0	33.6
2439.500	98.97	---	Fund.	-	H	231.0	90.0	33.6
4879.000	---	52.40	54.00	1.60	V	264.0	150.0	-1.7
4879.000	60.48	---	74.00	13.52	V	264.0	150.0	-1.7
Measurement uncertainty				+2.2 dB / -3.6 dB				

Transmitter operates at the upper end of the assigned frequency band (operation mode 3)

Frequency [MHz]	QuasiPeak [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Meas. Time [ms]	Bandwidth [kHz]	Height [cm]	Pol	Azimuth [deg]	Corr. [dB]
30.550000	21.29	40.00	18.71	1000.0	120.000	110.0	V	283.0	25.1
34.840000	15.90	40.00	24.10	1000.0	120.000	145.0	V	200.0	22.8
35.830000	15.69	40.00	24.31	1000.0	120.000	109.0	V	189.0	22.3
36.480000	15.95	40.00	24.05	1000.0	120.000	135.0	V	183.0	21.9
88.140000	10.19	43.50	33.31	1000.0	120.000	311.0	V	166.0	16.5
89.150000	9.47	43.50	34.03	1000.0	120.000	384.0	V	175.0	16.5
Measurement uncertainty					+2.2 dB / -3.6 dB				

Frequency [MHz]	MaxPeak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
2474.500	---	71.48	Fund.	-	H	244.0	90.0	33.6
2474.500	96.75	---	Fund.	-	H	244.0	90.0	33.6
4951.000	---	53.9	54.00	0.10	H	262.0	150.0	-1.8
4951.000	62.64	---	74.00	11.36	H	262.0	150.0	-1.8
Measurement uncertainty				+2.2 dB / -3.6 dB				

Test equipment (please refer to chapter 6 for details)
9 kHz – 30 MHz: 2 – 4, 6, 9, 10, 24 30 MHz – 1000 MHz: 28 - 35; 1 – 26.5 GHz: 2 - 11, 13, 16 - 22

6 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
2	Antenna mast	AS615P	Deisel	615/310	480187	Calibration not necessary	
3	Fully anechoic chamber M20	B83117-E2439-T232	Albatross Projects	103	480303	Calibration not necessary	
4	Turntable	DS420 HE	Deisel	420/620/00	480315	Calibration not necessary	
5	RF-cable No.3	Sucoflex 106B	Suhner	0563/6B / Kabel 3	480670	Calibration not necessary	
6	Multiple Control Unit	MCU	Maturo GmbH	MCU/043/971107	480832	Calibration not necessary	
7	Antenna (Log.Per.)	HL050	Rohde & Schwarz	100438	481170	09.10.2017	10.2020
8	RF-Cable No. 40	Sucoflex 106B	Suhner	0708/6B / Kabel 40	481330	Calibration not necessary	
9	Positioners	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not necessary	
10	EMI Receiver / Spectrum Analyser	ESW44	Rohde & Schwarz	101635	482467	29.03.2018	03.2020
11	HF-Cable	Sucoflex 104	Huber+Suhner	517408	482391	Calibration not necessary	
12	Antenna (Bilog)	CBL6112B	Schaffner EMV GmbH (-Chase)	2688	480328	19.06.2017	06.2020
13	Software	EMC32	Rohde & Schwarz	-	483261	Calibration not necessary	
14	RF-cable No.36	Sucoflex 106B	Suhner	0587/6B / Kabel 36	480865	Calibration not necessary	
15	HF-Cable	Sucoflex 104	Huber+Suhner	517402	482392	Calibration not necessary	
16	standard gain horn antenna	18240-20	Flann Microwave	483	480294	Calibration not necessary	
17	standard gain horn antenna	20240-20	Flann Microwave	411	480297	Calibration not necessary	
18	Microwave cable 2m	Insulated Wire Inc.	Insulated Wire	KPS-1533-800-KPS	480302	Calibration not necessary	
19	Preamplifier 100 MHz - 13 GHz	JS3-00101200-23-5A	MITEQ Hauppauge N.Y.	681851	480337	10.07.2018	07.2020
20	Preamplifier 18 GHz - 26 GHz	JS4-18002600-20-5A	MITEQ Hauppauge N.Y.	658697	480342	10.07.2018	07.2020
21	Preamplifier 12 GHz - 18 GHz	JS3-12001800-16-5A	MITEQ Hauppauge N.Y.	571667	480343	10.07.2018	07.2020
22	High pass Filter	WHKX4.0/18G-8SS	Wainwright Instruments GmbH	1	480587	Calibration not necessary	
24	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	21.02.2018	02.2020
27	Multiple Control Unit	MCU	Maturo	040/971107	480924	Calibration not necessary	
28	Semi anechoic chamber	M276	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
29	Antenna mast	BAM4.5-P-10kg	maturo	222/2612.01	483225	Calibration not necessary	
30	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
31	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
32	Software	EMC32	Rohde & Schwarz	ID: 1300.7010.12-100970-Be	482972	Calibration not necessary	
33	Ultralog Antenna	HL562E	Rohde & Schwarz	-	482978	07.08.2019	08.2022
34	EMI Testreceiver	ESW	Rohde & Schwarz	101828	482979	14.11.2019	11.2021
35	6 dB matching pad	WA2-6	Weinschel	-	482794	Calibration not necessary	

7 Report History

Report Number	Date	Comment
F191757E1	09.01.2020	Initial Test Report

8 List of Annexes

Annex A	Test Setup Photos	6 pages
Annex B	External Photos	4 pages
Annex C	Internal Photos	5 pages