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# Test Report

Report Number:

**F190261E5**

Equipment under Test (EUT):

**CargoTrac-ExR-M1**

Applicant:

**Savvy Telematic Systems AG**

Manufacturer:

**Savvy Telematic Systems AG**



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 (April 2018)**, 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 by	Paul NEUFELD Name	 Signature	18.07.2019 Date
Written by	Bernward ROHDE Name	 Signature	18.07.2019 Date
Reviewed and approved by:	Bernd STEINER Name	 Signature	18.07.2019 Date

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# 1 Identification

## 1.1 Applicant

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Country:	Switzerland
Name for contact purposes:	Mr. André SCHÄR
Phone:	+41-52-63346-00
eMail Address:	info@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:	info@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 Accreditation with the registration number 469623, designation number DE0004 and Industry Canada Test site registration SITE# IC3469A-1.

## 1.4 EUT (Equipment under Test)

EUT	
Test object: *	Autonomous Telematic Device
PMN / Model name: *	CargoTrac-(Ex)R-M1
FCC ID: *	2ATWF-CTEXRM1
ISED Certification number: * IC: *	25039-CTEXRM1
HVIN: *	1077
HMN: *	N/A
FVIN: *	v1.1.2-201905131349
Serial number: *	1077-000030
PCB identifier: *	CargoTrac-(Ex)R-M1 V1.0
Hardware version: *	V1.1
Software version: *	Build 2019-04-09 12:05:49

\* 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 <sup>*1</sup>	CTEXRM1 in Control-Terminal Mode Setting and USB Interface 014c5997190000f0
Antennas for control purposes <sup>*2</sup>	EMCO 3115 used outside the FAR RAD-ISM-2400-ANT-PAN-8-0, Phoenix Contact; used inside the FAR
Laptop PC: <sup>*2</sup>	Fujitsu Lifebook S751 (PM No. 201036)

<sup>\*1</sup> Provided by the applicant

<sup>\*2</sup> 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: *	Flex antenna					
Antenna name: *	FXP.74 Black Diamond 2.4 GHz Antenna Taoglas					
Antenna gain: *	Max +4 dBi					
Antenna connector: *	ufl. / (second antenna path disabled by software)					
Power supply EUT: *	DC (by internal batteries)					
Supply voltage EUT: *	U <sub>nom</sub> =	7.2 V	U <sub>min</sub> =	6.0 V	U <sub>max</sub> =	7.4 V
Supply voltage radio module: *	U <sub>nom</sub> =	3.3	U <sub>min</sub> =	3.23 V	U <sub>max</sub> =	3.39 V
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:	25.02.2019
Start of test:	08.05.2019
End of test:	20.05.2019

## 2 Operational States

The EUT is the radio part of an autonomous telematics system.  
The EUT has a built-in GSM/LTE and a IEEE 802.15.4 transceiver. This test report covers only the IEEE 802.15.4 specific test cases.

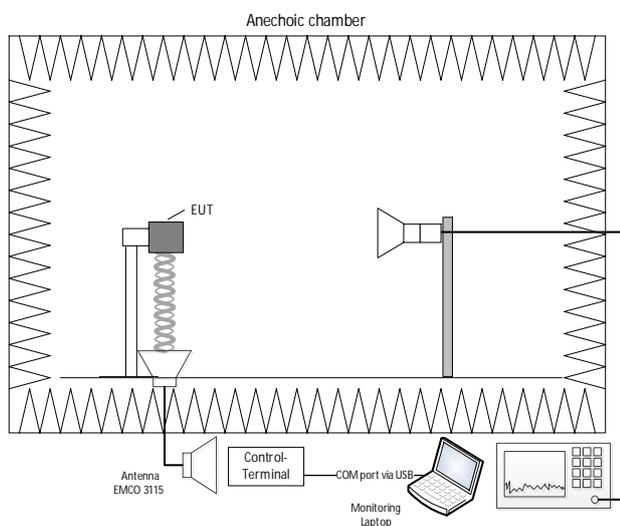
GSM/LTE module  
FCC ID: XPYUBX18ZO01  
IC: 8595A-UBX18ZO01

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.  
The setup was as following:



A connection to the EUT was established via the control-terminal.

### 2.1.1 Radio tests

The control terminal is a second “CargoTrac-(Ex)R-M1” 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:

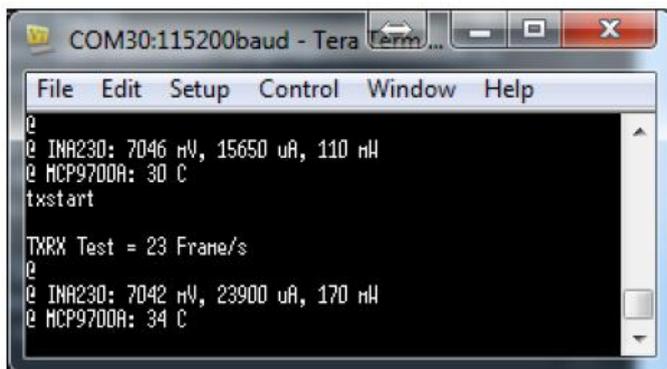
For the radio tests the following settings were used:

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 below shown interface was used to set the EUT in the applicable test-mode.



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\_CargoTrac-ExR-M1\_V1.3 by A. Schaer 22.05.2019)

### 2.1.2 Operation Modes

Operation Mode	Channel	Frequency [MHz]	Data rate	Power setting [dBm]
1	11	2405	250 kbit/s	-6.5
2	18	2440	250 kbit/s	-6.5
3	25*	2475	250 kbit/s	-6.5

\* 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

For simplification a plot of one mode each was added here. All other results are listed in the tables for each testcase.

The tested EUT was not labeled with the final label.

### 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	14 et seq.
Maximum conducted peak output power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [3]	Passed <sup>*1</sup>	13 et seq.
Maximum conducted (average) output power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [3]	Passed <sup>*1</sup>	13 et seq.
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [3]	Passed	19 et seq.
Average Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [3]	Passed	19 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	21 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	25 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Not applicable <sup>*2</sup>	---

<sup>\*1</sup> Antenna gain does not exceed 6 dBi, no power reduction necessary

<sup>\*2</sup> EUT is battery supplied only, without any possibility of charging

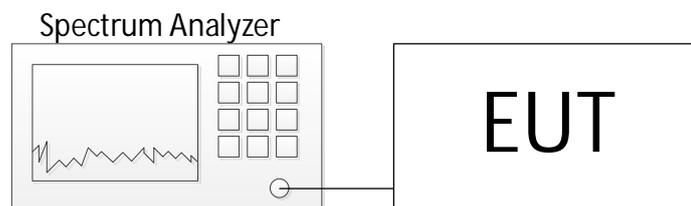
## 5 Results

### 5.1 Duty cycle

#### 5.1.1 Method of measurement (conducted)

The measurement was performed as an antenna port conducted measurement, as shown below.

Test Setup:



The method described in chapter 11. b) of document [1] or 6 b) of document [5] was used to perform the following test.

Only the worst case plot for each mode was submitted below.

The following measurement technique was used:

The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between two bins on the sweep are sufficient to permit accurate measurements of the on and off times of the transmitted signal.

- Set the center frequency of the instrument to the center frequency of the transmission.
- Set  $RBW \geq OBW$  if possible; otherwise, set RBW to the largest available value.
- Set  $VBW \geq RBW$ .
- Set detector = peak or average.
- The zero-span measurement method shall not be used unless both RBW and VBW are  $> 50/T$  and the number of sweep points across duration T exceeds 100. (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if  $T \leq 16.7$  microseconds.)

### 6.1.1 Test results (conducted)

Ambient temperature	22 °C
Relative humidity	32 %

Date	08.05.2019
Tested by	P. NEUFELD

Operation mode	TX_on [µs]	TX_ges [µs]	RBW [MHz]	50/T [kHz]	50/T < RBW?
1	1313	18306	3	38	Yes

Operation mode	Sweep points	Sweep time [µs]	Meas points	Meas points >100?	Duty cycle %	DCCF [dB]
1	10001	22000	8322	Yes	7	11.44

The DCCF (duty cycle correction factor) is calculated by:

$$DCCF = 10 * \log_{10} \left( \frac{1}{Duty\ cycle} \right)$$

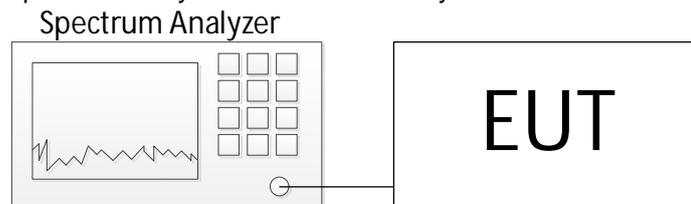
The duty cycle is smaller than 98%, therefore, for average measurements a correction factor of 11.44 dB is used.

Test equipment (please refer to chapter 6 for details)
1

## 6.2 DTS Bandwidth / 99% Bandwidth

### 6.2.1 Method of measurement (conducted)

The EUT was tested with a spectrum analyzer connected directly to the EUT.



DTS bandwidth:

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

- Set RBW = 100 kHz.
- Set the video bandwidth (VBW)  $\geq 3 \times$  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:

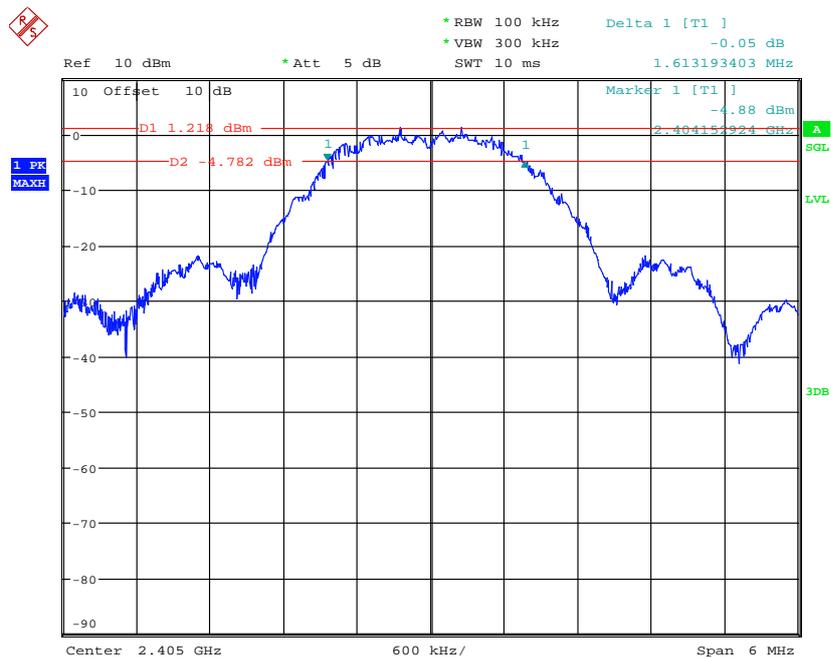
- The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
- The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately 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  $[10 \log (\text{OBW}/\text{RBW})]$  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).

### 6.2.2 Test results (conducted)

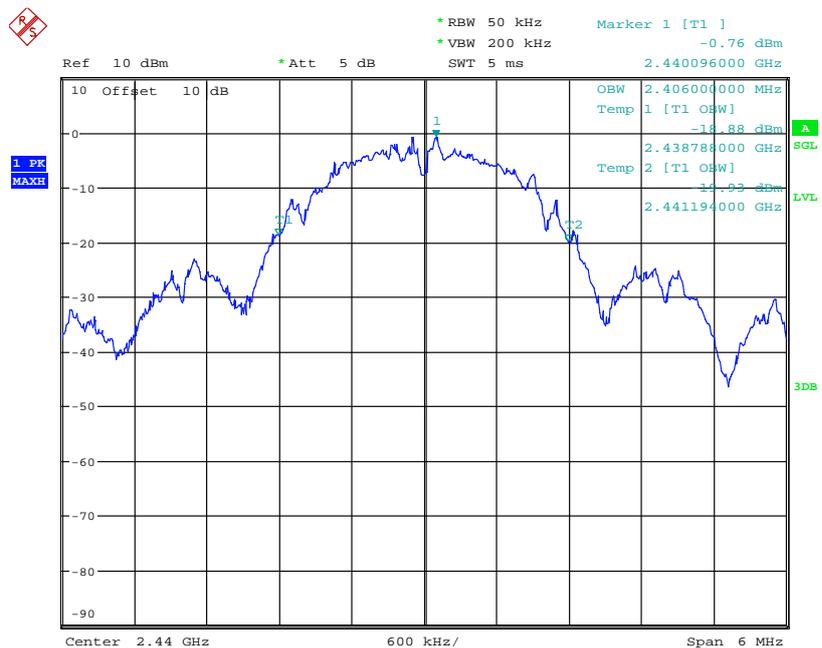
Ambient temperature	22 °C
Relative humidity	32 %

Date	08.05.2019
Tested by	P. NEUFELD

DTS bandwidth (Operation mode 1):



99% bandwidth (Operation mode 2):



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	1.613	2.388	Passed
2	250 kbit/s	2440	0.5	1.625	2.406	Passed
3	250 kbit/s	2475	0.5	1.649	2.275	Passed

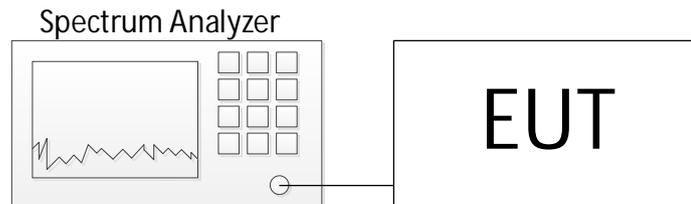
Test equipment (please refer to chapter 6 for details)

1

## 6.3 Maximum peak conducted output power

### 6.3.1 Method of measurement (conducted)

The EUT was measured conducted at the antenna ports with the aid of a spectrum analyzer.



#### Acceptable measurement configurations

Procedure 11.9.1.1 in [1] was used for the following test.

The following procedure shall be used when an instrument with a resolution bandwidth that is greater than the DTS bandwidth is available to perform the measurement:

- Set the  $RBW \geq DTS$  bandwidth.
- Set  $VBW \geq [3 \times RBW]$ .
- Set  $span \geq [3 \times RBW]$ .
- Sweep time = auto couple.
- Detector = peak.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use peak marker function to determine the peak amplitude level.

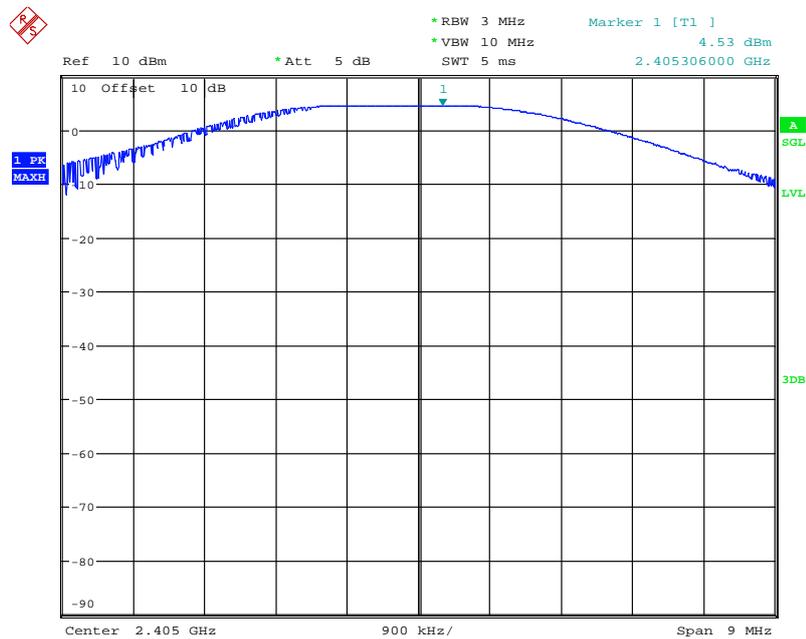
The measurement was performed at the upper and lower end and the middle of the assigned frequency band.

### 6.3.2 Test results (conducted)

Ambient temperature	22 °C
Relative humidity	32 %

Date	08.05.2019
Tested by	P. NEUFELD

Maximum peak output power (Operation mode 1):



Operation mode	Data rate	Frequency [MHz]	Result [dBm]	Limit [dBm]
1	250 kbit/s	2405	4.5	30
2	250 kbit/s	2440	4.4	30
3	250 kbit/s	2475	4.3	30

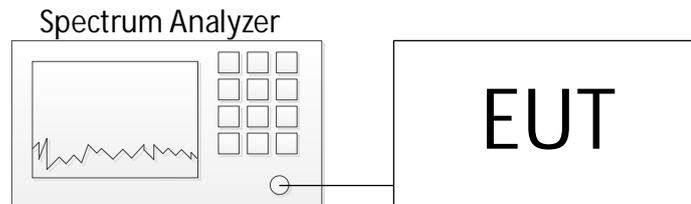
The antenna gain is below 6 dBi, therefore no conducted output limit reduction is necessary.

Test equipment (please refer to chapter 6 for details)
1

## 6.4 Peak Power Spectral Density

### 6.4.1 Method of measurement (conducted)

The EUT was tested with a spectrum analyzer connected directly to the EUT.



The measurement procedure refers to part 11.10.2 of document [1].

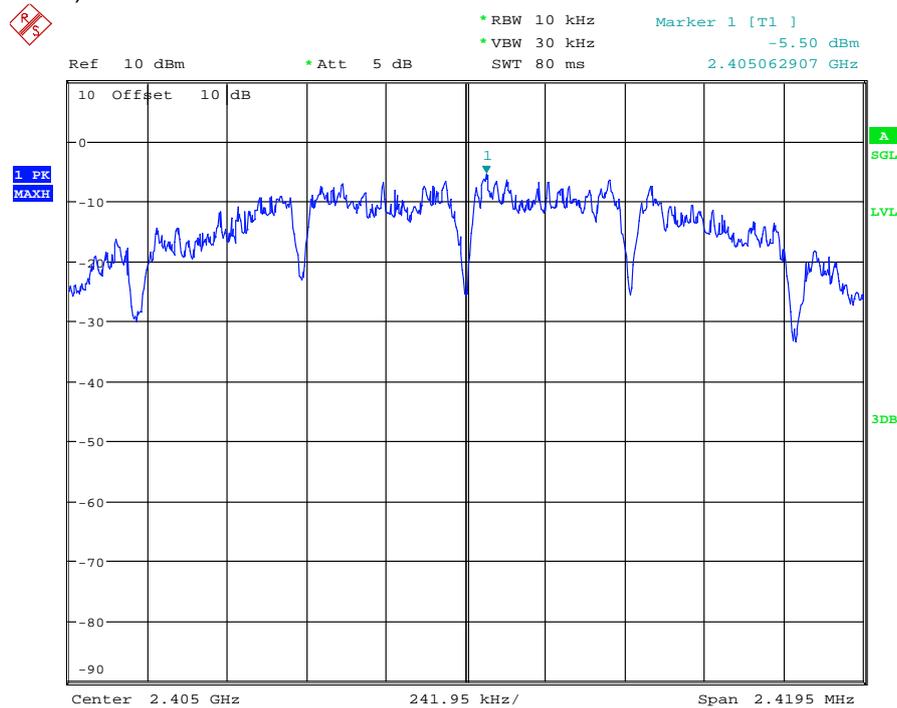
- Set analyzer center frequency to DTS channel center frequency.
- Set the span to 1.5 times the DTS bandwidth.
- Set the RBW to  $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$ .
- Set the VBW  $\geq [3 \times \text{RBW}]$ .
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level within the RBW.
- If measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat.

### 6.4.2 Test results (conducted)

Ambient temperature	22 °C
Relative humidity	32 %

Date	08.05.2019
Tested by	P. NEUFELD

PSD (Operation mode 1):



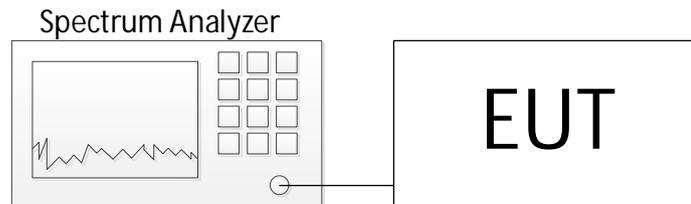
OP mode	Data rate	Peak Frequency [MHz]	Result [dBm / 10 kHz]	PSD Limit [dBm / 3 kHz]	Result
1	250 kbit/s	2405.063	-5.5	8	Passed
2	250 kbit/s	2440.063	-5.8	8	Passed
3	250 kbit/s	2475.062	-6.3	8	Passed

Test equipment (please refer to chapter 6 for details)
1

## 6.5 Band-edge compliance

### 6.5.1 Method of measurement (band edges next to unrestricted bands (conducted))

The EUT was tested with a spectrum analyzer connected directly to the EUT.



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  $\geq 1.5$  times the DTS Bandwidth.
- RBW = 100 kHz.
- VBW  $\geq 300$  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  $\geq 300$  kHz.
- Detector = Peak.
- Ensure that the number of measurement points  $\geq \text{span}/\text{RBW}$ .
- Sweep time = auto couple.
- Trace Mode = max hold.
- Allow the trace to stabilize.
- Use the peak marker function to determine the maximum amplitude level.

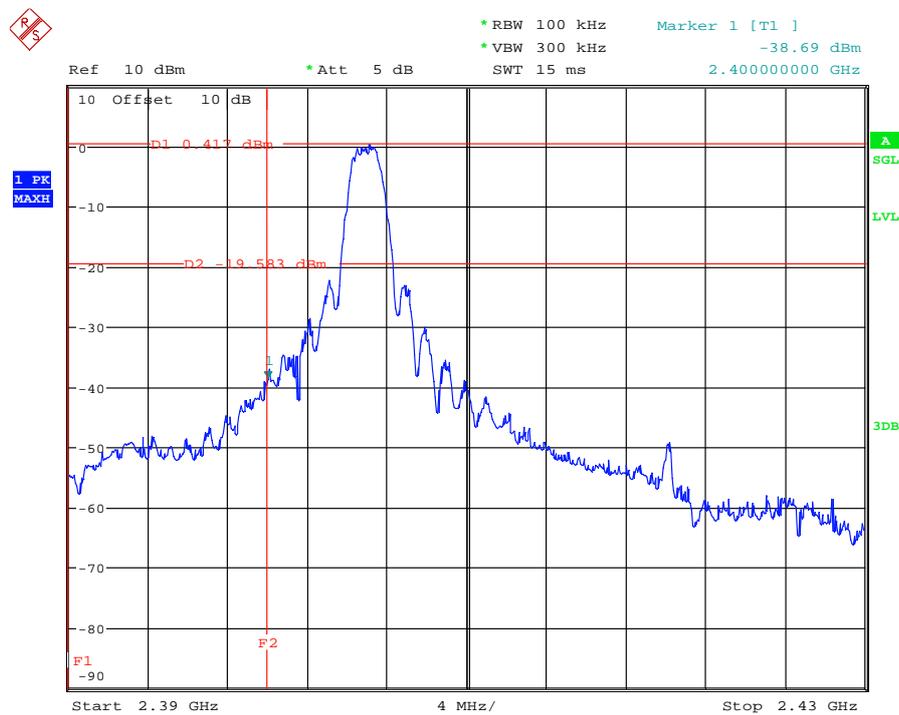
The measurement procedure at the band edges was simplified by performing the measurement in just one plot. Both, the in-band-emission and the unwanted emission were be encompassed by the span. After trace stabilization, the maximum peak was be determined by a peak detector and the value was marked by 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.

### 6.5.2 Test results (conducted)

Ambient temperature	22 °C
Relative humidity	32 %

Date	08.05.2019
Tested by	P. NEUFELD

Unrestricted band edge (Operation mode 1):



Operation mode	Data rate	Frequency [MHz]	Reference Level [dBm]	Limit [dBm]	Emission Level [dBm]	Margin [dB]	Result
1	250 kbit/s	2400.000	0.4	-19.6	-38.5	18.9	Passed

Test equipment (please refer to chapter 6 for details)
1

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

#### Acceptable measurement configurations

The same measurement configuration as described in 6.6.1 was used for the preview and final measurement of the peak values.

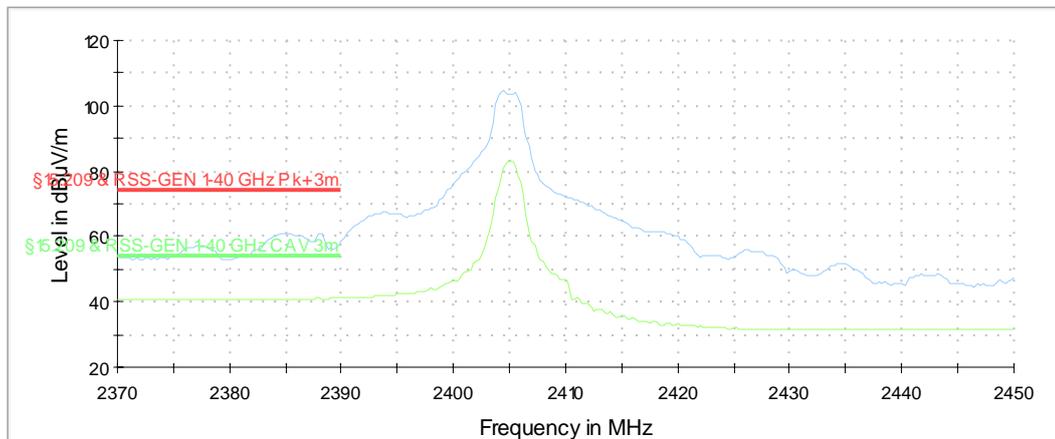
The average value was determined by using method 11.12.2.5.3 of document [1]

### 6.5.4 Test results (radiated)

Ambient temperature	22 °C
Relative humidity	40 %

Date	17.05.2019
Tested by	P. NEUFELD

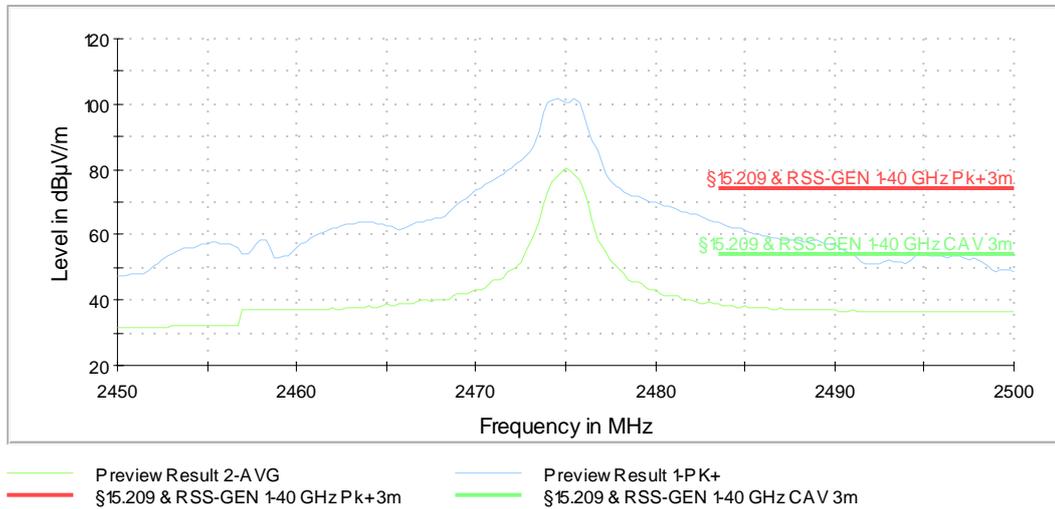
Restricted band edge (Operation mode 1):



— Preview Result 2-AVG  
— §15.209 & RSS-GEN 1-40 GHz Pk+3m  
— Preview Result 1PK+  
— §15.209 & RSS-GEN 1-40 GHz CAV 3m

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]	
2390.000	58.7	-	74.0	15.3	V	253	120	33.0	Passed
2390.000	-	46.7	54.0	7.3	V	253	120	33.0	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 [MHz]	Max Peak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Pol	Azimuth [°]	Elevation [°]	Correction [dB]	Result
2484.000	63.6	---	74.0	10.4	V	191	60	33.6	Passed
2484.000	---	45.5	54.0	8.5	V	191	60	33.6	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB					

Test equipment (please refer to chapter 6 for details)

2 - 11

## 6.6 Maximum unwanted emissions

### 6.6.1 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 measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 30 MHz to 1 GHz.
- A final measurement carried out on an open area test site 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 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.

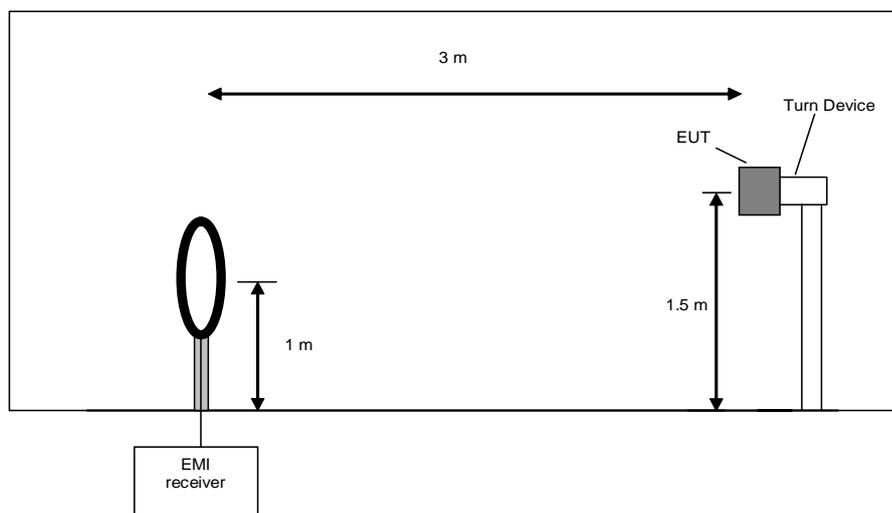
#### **Preliminary measurement (9 kHz to 30 MHz):**

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



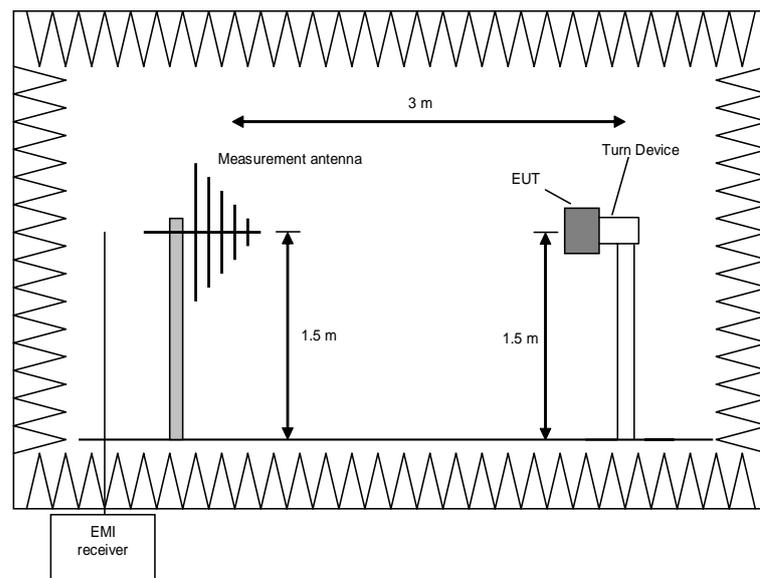
### Preliminary measurement (30 MHz to 1 GHz)

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. 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 30 MHz to 1 GHz will be measured with an EMI Receiver 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
30 MHz to 230 MHz	100 kHz
230 MHz to 1 GHz	100 kHz



### Procedure preliminary measurement:

Pre scans were performed in the frequency range 30 MHz to 230 MHz and 230 MHz to 1 GHz. The following procedure will be used:

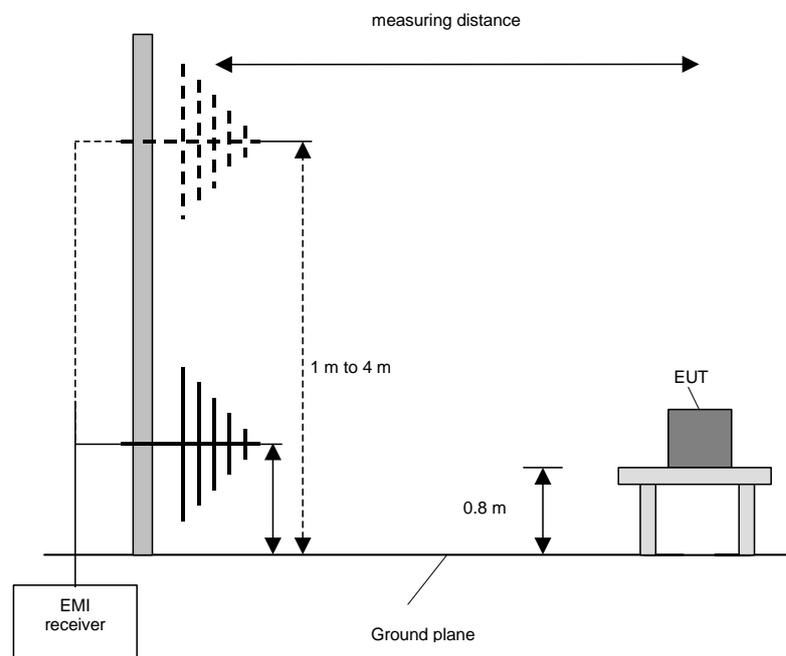
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Repeat 1) to 3) with the vertical polarisation of the measuring antenna.
5. Make a hardcopy of the spectrum.
6. Repeat 1) to 5) with the EUT raised by an angle of 0° (45°, 90°) according to 6.6.5.4 in [1].
7. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.

### Final measurement (30 MHz to 1 GHz)

A final measurement on an open area test site will be performed on selected frequencies found in the preliminary measurement. During this test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarisation 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:

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	120 kHz



### Procedure final measurement:

The following procedure will be used:

- 1) Measure on the selected frequencies at an antenna height of 1 m and a EUT azimuth of 23 °.
- 2) Move the antenna from 1 m to 4 m and note the maximum value at each frequency.
- 3) Rotate the EUT by 45 ° and repeat 2) until an azimuth of 337 ° is reached.
- 4) Repeat 1) to 3) for the other orthogonal antenna polarization.
- 5) Move the antenna and the turntable to the position where the maximum value is detected.
- 6) Measure while moving the antenna slowly +/- 1 m.
- 7) Set the antenna to the position where the maximum value is found.
- 8) Measure while moving the turntable +/- 45 °.
- 9) Set the turntable to the azimuth where the maximum value is found.
- 10) Measure with Final detector (QP and AV) and note the value.
- 11) Repeat 5) to 10) for each frequency.
- 12) Repeat 1) to 11) for each orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).

**Preliminary and final measurement (1 GHz to 40 GHz)**

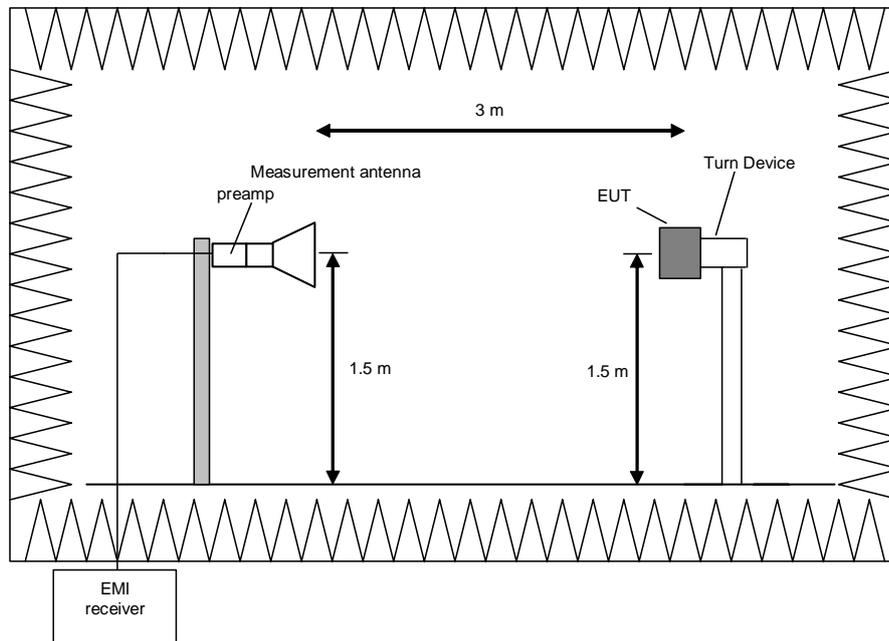
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

**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	100 kHz
4 GHz to 12 GHz	100 kHz
12 GHz to 18 GHz	100 kHz
18 GHz to 25 / 26.5 GHz	100 kHz
26.5 GHz to 40 GHz	100 kHz



Procedure preliminary measurement:

Pre scans were performed in the frequency range 1 to 40 GHz.

The following procedure will be used:

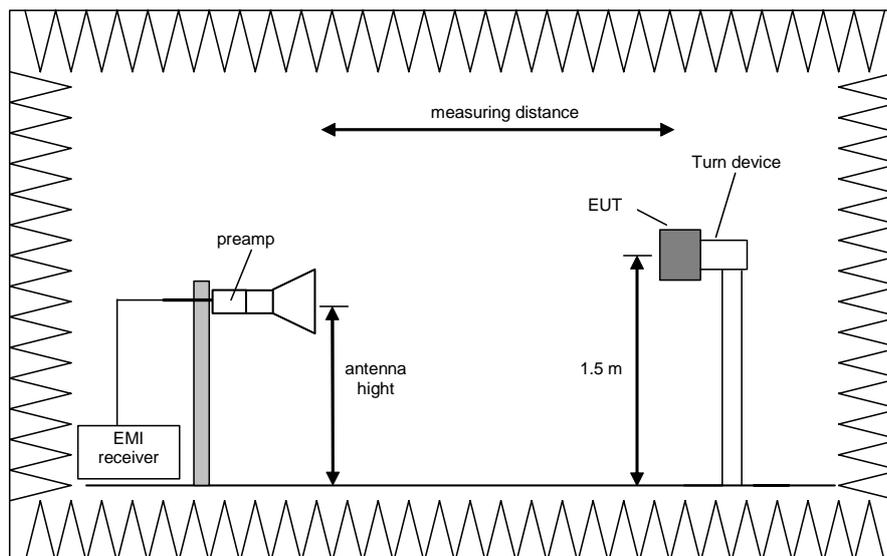
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an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

**6.6.2 Test results (radiated emissions) – Emissions from 30 MHz – 26.5 GHz**

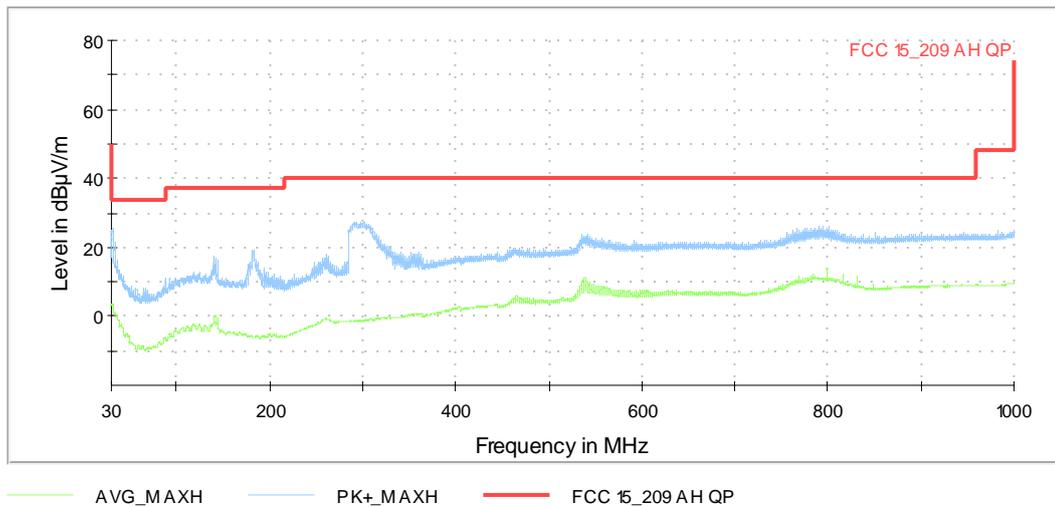
**6.6.2.1 Preliminary radiated emission measurement 30 MHz – 26.5 GHz**

Ambient temperature	22 °C	Date	20.05.2019
Relative humidity	59 %	Tested by	P. NEUFELD

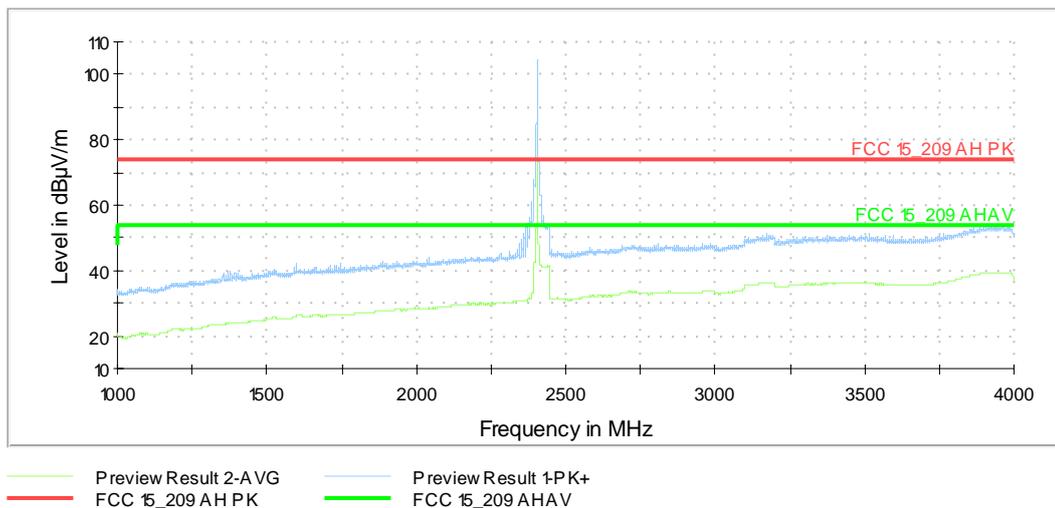
- Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.
- For the final test on the open area test site the EUT was placed on a table with the height of 0.8 m. The distance between EUT and antenna was 3 m.
- Cable guide: For detail 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: Since there were no differences in the spectrum for  $f < 1$  GHz, only one representative plot is submitted below.
- No Emissions greater than 30 dB to the limit was found below 30 MHz during the preliminary test, therefore no final test was performed.

**Plots of the worst case transmitter spurious emissions**

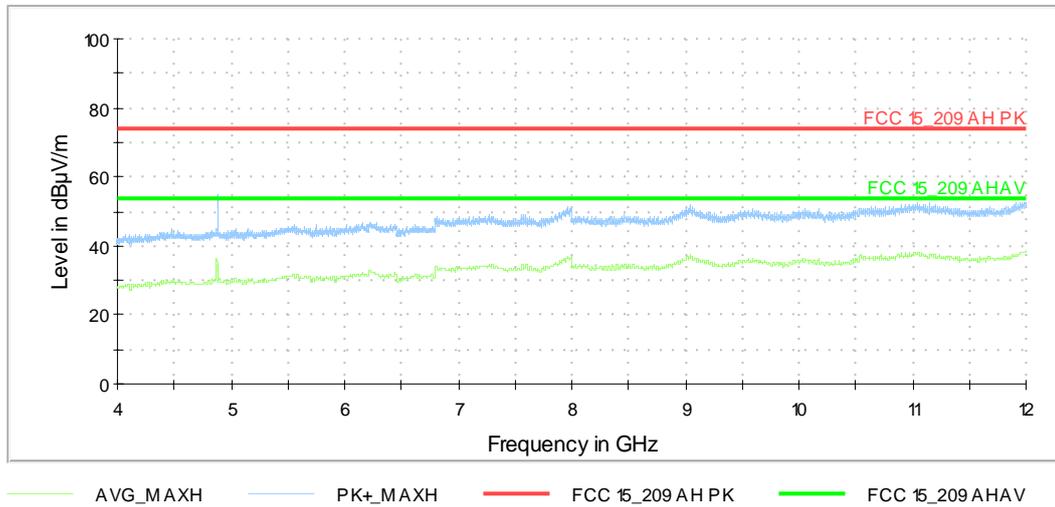
190261\_Ch11\_30M-1G\_AH: Spurious emissions from 30 MHz to 1 GHz (operation mode 1):  
Preliminary plot



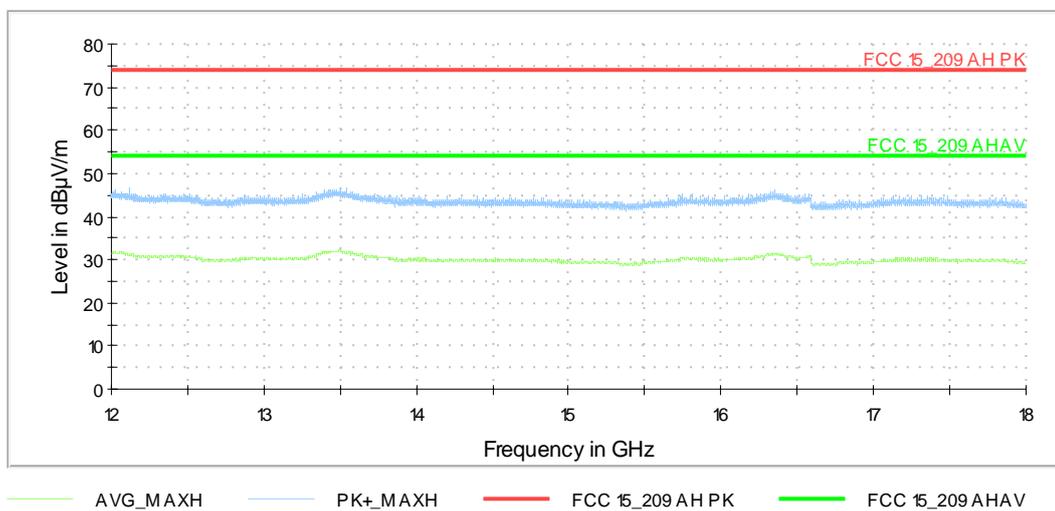
190261\_Ch11\_1-4G: Spurious emissions from 1 GHz to 4 GHz (operation mode 1)  
Preliminary plot – no final measurement conducted



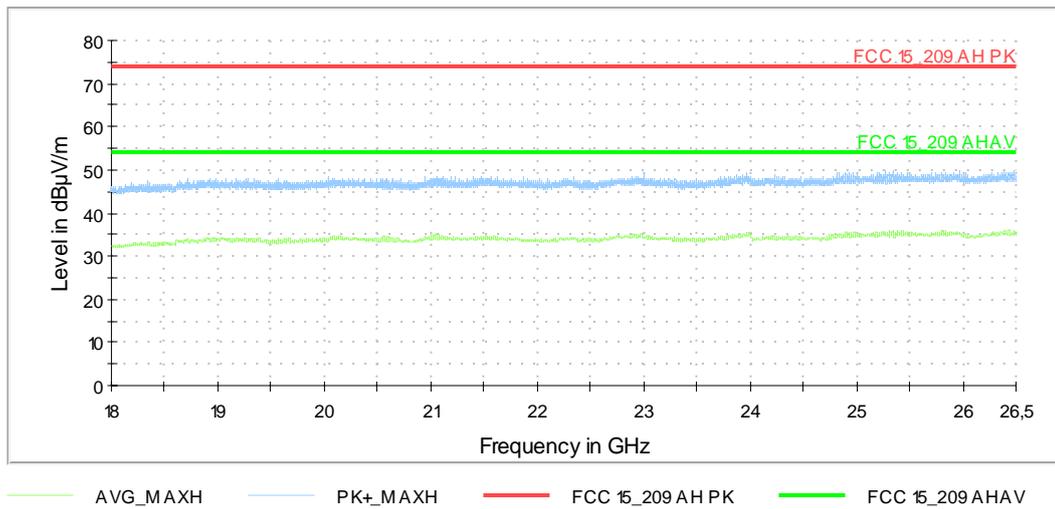
190261\_Ch18\_4-12G: Spurious emissions from 4 GHz to 12 GHz (operation mode 2):  
Preliminary plot



190261\_Ch11\_12-18G: Spurious emissions from 12 GHz to 18 GHz (operation mode 1):  
Preliminary plot - no final measurement conducted



190261\_Ch11\_18-26,5G: Spurious emissions from 18 GHz to 26.5 GHz (operation mode 3):  
Preliminary plot - no final measurement conducted



### 6.6.2.2 Final radiated measurements

**All TX modes (no difference detected when comparing channel)**

Frequency [MHz]	QuasiPeak [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Meas. Time [ms]	Bandwidth [kHz]	Height [cm]	Pol	Azimuth [deg]	Corr. [dB]
31.025	29.7	40.0	10.3	1000	120	118	V	277	26.7
31.050	29.0	40.0	11.0	1000	120	124	V	238	26.7
104.625	21.2	43.5	22.3	1000	120	302	H	227	17.3
123.175	17.3	43.5	26.2	1000	120	104	V	181	19.0
141.000	17.3	43.5	26.2	1000	120	107	V	76	18.9
540.450	26.6	46.0	19.4	1000	120	290	V	311	28.1
541.225	26.5	46.0	19.5	1000	120	400	V	91	28.2
801.050	35.9	46.0	10.1	1000	120	400	H	214	32.1
Measurement uncertainty					+2.2 dB / -3.6 dB				

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

Frequency [MHz]	MaxPeak [dB $\mu$ V/m]	Average [dB $\mu$ V/m]	Limit [dB $\mu$ V/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
4810.000000	---	48.0	54	6.0	V	295	60	-2.0
4810.000000	53.3	---	74	20.7	V	295	60	-2.0
Measurement uncertainty				+2.2 dB / -3.6 dB				

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

Frequency [MHz]	MaxPeak [dB $\mu$ V/m]	Average [dB $\mu$ V/m]	Limit [dB $\mu$ V/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
4880.000000	54.9	---	74	19.1	V	271	60	-2.0
4880.000000	---	51.1	54	2.9	V	271	60	-2.0
Measurement uncertainty				+2.2 dB / -3.6 dB				

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

Frequency [MHz]	MaxPeak [dB $\mu$ V/m]	Average [dB $\mu$ V/m]	Limit [dB $\mu$ V/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
4951.000000	54.0	---	74	20.0	V	311	60	-2.0
4951.000000	---	45.5	54	8.5	V	311	60	-2.0
Measurement uncertainty				+2.2 dB / -3.6 dB				

Test equipment (please refer to chapter 6 for details)	
Preliminary measurements:	9 kHz – 30 MHz: 30, 30 MHz – 1000 MHz: 2 - 4, 6, 9 - 10, 12 – 15; 1 – 26.5 GHz: 2 - 10, 13, 16 - 22
Final measurements:	30 – 1000 MHz: 23 – 29 ; 1 – 26.5 GHz: 2 - 10, 13, 16 - 22

## 7 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Spectrum Analyser	FSU46	Rohde & Schwarz	200125	480956	31.10.2018	10.2019
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	WMS32	Rohde & Schwarz		481800	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	
23	Open area test site M6	Freifeld M6	Phoenix Contact	-	480085	Calibration not necessary	
24	Antenna mast	MA240-0	Inn-Co GmbH	MA240-0/030/6600603	480086	Calibration not necessary	
25	Turntable	DS412	Deisel	412/316	480087	Calibration not necessary	
26	Controller	HD100	Deisel	100/349	480139	Calibration not necessary	
27	Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
28	Antenna (Bilog)	CBL6111D	Schaffner Elektrotest GmbH / Teseq GmbH	25761	480894	19.10.2017	10.2020
29	Measuring receiver	ESR7	Rohde & Schwarz	101939	482558	19.09.2017	09.2019
30	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	21.02.2018	02.2020
31	Fully anechoic chamber M5	B83117-S1-X156	Siemens	B83117-S1-X156	480073	Calibration not necessary	
32	EMI Receiver / Spectrum Analyser	ESR7	Rohde & Schwarz	101939	482558	19.09.2017	09.2019
33	Multiple Control Unit	MCU	Maturo	040/971107	480924	Calibration not necessary	

## 8 Report History

Report Number	Date	Comment
F190261E5	18.07.2019	Initial Test Report

## 9 List of Annexes

Annex A	Test Setup Photos	8 pages
Annex B	External Photos	4 pages
Annex C	Internal Photos	11 pages