

# FCC Measurement/Technical Report on

## Radio Identification Device

### FS197

### Part of system “37W”

FCC ID: NBGFS197  
IC: 2694A-FS197

**Test Report Reference:** MDE\_HELLA\_1806\_FCCe\_REV3

**Test Laboratory:**

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**Note:**

The following test results relate only to the devices specified in this document. This report shall not be reproduced in parts without the written approval of the test laboratory.

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## Applied Standards and Test Summary

## 1.1 APPLIED STANDARDS

### **Applicable FCC Rules**

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15 (10-1-18 Edition). The following subparts are applicable to the results in this test report.

### **Part 2, Subpart J - Equipment Authorization Procedures, Certification**

### **Part 15, Subpart F – Ultra Wideband Operation**

- § 15.201 Equipment authorization requirement
- § 15.207 Conducted limits
- § 15.209 Radiated emission limits; general requirements
- § 15.503 Definitions
- § 15.519 Technical Requirements for hand held UWB devices
- § 15.521 Technical requirements applicable for all UWB devices

Note:  
ANSI C63.10–2013 is applied.

## Summary Test Results:

The EUT complied with all performed tests as listed in chapter 1.3 Measurement Summary / Signatures.

## 1.2 FCC-IC CORRELATION TABLE

### Correlation of measurement requirements for handheld UWB equipment from FCC and IC

| Measurement                                        | FCC reference                  | IC reference                                                                 |
|----------------------------------------------------|--------------------------------|------------------------------------------------------------------------------|
| Conducted emissions on AC Mains                    | § 15.207                       | RSS-Gen Issue 5: 8.8                                                         |
| -10 dB Occupied bandwidth                          | § 15.503 (d);<br>§ 15.519 (b)  | RSS-220 Issue 1: 2;<br>RSS-220 Issue 1: 5.1 (a);<br>RSS-220 Issue 1: Annex 2 |
| Peak Emission                                      | § 15.519 (e);<br>§ 15.521 (e)  | RSS-220 Issue 1: 5.3.1 (g)<br>RSS-220 Issue 1: Annex 4                       |
| Transmitter spurious radiated emissions            | § 15.209 (a);<br>§ 15.519 (c); | RSS-220 Issue 1: 3.4;<br>RSS-220 Issue 1: 5.3.1 (c), (d)                     |
| Transmitter spurious radiated emissions GNSS bands | § 15.519 (d)                   | RSS-220 Issue 1: 5.3.1 (e)                                                   |
| Transmission time                                  | § 15.519 (a) (1)               | RSS-220 Issue 1: 5.3.1 (b)                                                   |

### 1.3 MEASUREMENT SUMMARY / SIGNATURES

#### 47 CFR CHAPTER I FCC PART 15 Subpart F § 15.207

Conducted Emissions at AC mains

The measurement was performed according to ANSI C63.10

**Final Result**

##### OP-Mode

AC mains connection, Test setup

##### Setup

##### FCC

##### IC

-, -

-

N/A

N/A

#### 47 CFR CHAPTER I FCC PART 15 Subpart F § 15.503 (d)

-10 dB Occupied Bandwidth

The measurement was performed according to ANSI C63.10

**Final Result**

##### OP-Mode

Measurement method, Operating band, Channel

##### Setup

##### FCC

##### IC

radiated, 3100-10600 MHz, Low

S01\_AA10

Passed

Passed

radiated, 3100-10600 MHz, Mid

S01\_AA10

Passed

Passed

radiated, 3100-10600 MHz, High

S01\_AA10

Passed

Passed

#### 47 CFR CHAPTER I FCC PART 15 Subpart F § 15.519 (b)

-10 dB Occupied Bandwidth

The measurement was performed according to ANSI C63.10

**Final Result**

##### OP-Mode

Measurement method, Operating band, Channel

##### Setup

##### FCC

##### IC

radiated, 3100-10600 MHz, Low

S01\_AA10

Passed

Passed

radiated, 3100-10600 MHz, Mid

S01\_AA10

Passed

Passed

radiated, 3100-10600 MHz, High

S01\_AA10

Passed

Passed

#### 47 CFR CHAPTER I FCC PART 15 Subpart F § 15.519 (e)

Peak Emission

The measurement was performed according to ANSI C63.10

**Final Result**

##### OP-Mode

Measurement method, Operating band, Channel

##### Setup

##### FCC

##### IC

radiated, 3100-10600 MHz, Low

S01\_AA10

Passed

Passed

radiated, 3100-10600 MHz, Mid

S01\_AA10

Passed

Passed

radiated, 3100-10600 MHz, High

S01\_AA10

Passed

Passed

#### 47 CFR CHAPTER I FCC PART 15 Subpart F § 15.521 (e)

Peak Emission

The measurement was performed according to ANSI C63.10

**Final Result**

##### OP-Mode

Measurement method, Operating band, Channel

##### Setup

##### FCC

##### IC

radiated, 3100-10600 MHz, Low

S01\_AA10

Passed

Passed

radiated, 3100-10600 MHz, Mid

S01\_AA10

Passed

Passed

radiated, 3100-10600 MHz, High

S01\_AA10

Passed

Passed

#### 47 CFR CHAPTER I FCC PART 15 Subpart F

#### § 15.209 (a) / § 15.519 (c)

##### Radiated Emissions

The measurement was performed according to ANSI C63.10

##### Final Result

##### OP-Mode

Measurement method, Operating band, Measurement range, Channel

##### Setup

##### FCC

##### IC

|                                                  |          |        |        |
|--------------------------------------------------|----------|--------|--------|
| radiated, 3100-10600 MHz, 9 kHz – 30 MHz, Low    |          | Passed | Passed |
| radiated, 3100-10600 MHz, 30 MHz – 960 MHz, Low  | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 960 MHz – 18 GHz, Low  | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 18 GHz – 26 GHz, Low   | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 26 GHz – 40 GHz, Low   | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 9 kHz – 30 MHz, Mid    | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 30 MHz – 960 MHz, Mid  | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 960 MHz – 18 GHz, Mid  | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 18 GHz – 26 GHz, Mid   | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 26 GHz – 40 GHz, Mid   | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 9 kHz – 30 MHz, High   | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 30 MHz – 960 MHz, High | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 960 MHz – 18 GHz, High | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 18 GHz – 26 GHz, High  | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 26 GHz – 40 GHz, High  | S01_AA10 | Passed | Passed |

#### 47 CFR CHAPTER I FCC PART 15 Subpart F

#### § 15.519 (d)

##### Radiated Emissions in GNSS bands

The measurement was performed according to ANSI C63.10

##### Final Result

##### OP-Mode

Measurement method, Operating band, Measurement range, Channel

##### Setup

##### FCC

##### IC

|                                                     |          |        |        |
|-----------------------------------------------------|----------|--------|--------|
| radiated, 3100-10600 MHz, 1164 MHz – 1240 MHz, Low  | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 1164 MHz – 1240 MHz, Mid  | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 1164 MHz – 1240 MHz, High | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 1559 MHz – 1610 MHz, Low  | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 1559 MHz – 1610 MHz, Mid  | S01_AA10 | Passed | Passed |
| radiated, 3100-10600 MHz, 1559 MHz – 1610 MHz, High | S01_AA10 | Passed | Passed |

#### 47 CFR CHAPTER I FCC PART 15 Subpart F

#### § 15.519 (a) (1)

##### Associated Receiver / Transmissions times

The measurement was performed according to ANSI C63.10

##### Final Result

##### OP-Mode

Measurement method, Operating band, Channel, Test Setup

##### Setup

##### FCC

##### IC

|                                                       |          |        |        |
|-------------------------------------------------------|----------|--------|--------|
| radiated, 3100-10600 MHz, Low, Transmission time      | S01_SYS3 | Passed | Passed |
| radiated, 3100-10600 MHz, Mid, Associated Receiver    | S01_SYS1 | Passed | Passed |
| radiated, 3100-10600 MHz, Mid, No Associated Receiver | S01_SYS2 | Passed | Passed |

N/A: Not applicable

N/P: Not performed

## Revision History

| Report version control |              |                                                                                                                                                                                                                                                                                                                                                                |                  |
|------------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| Version                | Release date | Change Description                                                                                                                                                                                                                                                                                                                                             | Version validity |
| initial                | 2019-04-08   | --                                                                                                                                                                                                                                                                                                                                                             | invalid          |
| REV1                   | 2019-06-04   | <ul style="list-style-type: none"> <li>Page 10: EUT E, conducted sample added</li> <li>Page 11: Setup S01_AA13 added</li> <li>Page 44: Plots exchanged, to show that emissions at 3024 MHz are not emitted by the antenna</li> <li>Page 51: Adding references in the signaling sequences to the corresponding plots</li> </ul>                                 | invalid          |
| REV2                   | 2019-06-27   | <ul style="list-style-type: none"> <li>Page 45: Reference added that for the radiated part of the measurement with setup S01_AA13 the default radiated test setup was used and for the conducted part the conducted test setup.</li> <li>Page 32: Conducted test setup diagram for the conducted part of the measurement with setup S01_AA13 added.</li> </ul> | invalid          |
| REV3                   | 2019-07-26   | <ul style="list-style-type: none"> <li>Page 10: EUT F, radiated sample added</li> <li>Page 11: Setup S01_SYS3 added</li> <li>Page 52: test setup description for the transmission timing test setup exchanged</li> <li>Page 54/55: New transmission timing plots and explanations added</li> </ul>                                                             | valid            |

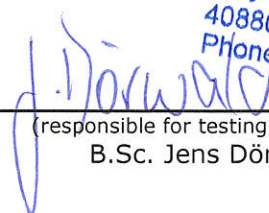
For the tests "Associated Receiver / Transmission Times a FS19 key FOB was used, because the results of this tests depend only on the software of the device and according customers declaration the software of both devices is absolute identical.

For details please see HELLA technical bulletin:

"Technical\_Bulletin\_FS19\_VW\_AUDI\_SYSTEM\_PERFORMANCE.PDF"



(responsible for accreditation scope)  
Dipl.-Ing. Marco Kullik



(responsible for testing and report)  
B.Sc. Jens Dörwald



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## 2 ADMINISTRATIVE DATA

### 2.1 TESTING LABORATORY

Company Name: 7layers GmbH  
Address: Borsigstr. 11  
40880 Ratingen  
Germany

The test facility is accredited by the following accreditation organisation:

Laboratory accreditation no: DAKKS D-PL-12140-01-00  
FCC Designation Number: DE0015  
FCC Test Firm Registration: 929146  
ISED CAB Identifier: DE0007; ISED#:3699A  
Responsible for accreditation scope: Dipl.-Ing. Marco Kullik  
Report Template Version: 2019-06-04

### 2.2 PROJECT DATA

Responsible for testing and report: B.Sc. Jens Dörwald  
Employees who performed the tests: documented internally at 7layers  
Date of Report: 2019-07-26  
Testing Period: 2018-12-10 to 2019-07-25

### 2.3 APPLICANT DATA

Company Name: HELLA GmbH & Co. KGaA  
Address: Rixbecker Str. 75  
59557 Lippstadt  
Germany  
Contact Person: Mr. Christian Elbers

### 2.4 MANUFACTURER DATA

Company Name: please see Applicant Data  
Address:  
Contact Person:

### 3 TEST OBJECT DATA

#### 3.1 GENERAL EUT DESCRIPTION

|                                          |                                                                                                                                                                                                                                                                    |
|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Kind of Device<br>product description    | The EUT is a handheld remote keyless transceiver with 125 kHz, 433 MHz and UWB technology.                                                                                                                                                                         |
| Product name                             | Radio Identification Device, part of system "37W"                                                                                                                                                                                                                  |
| Type                                     | FS197                                                                                                                                                                                                                                                              |
| <b>Declared EUT data by the supplier</b> |                                                                                                                                                                                                                                                                    |
| Power Supply Type                        | DC, Li coin cell<br><br>Note:<br>Before start of each tests a fresh battery was installed in the EUT.                                                                                                                                                              |
| Normal Voltage                           | 3.0 V                                                                                                                                                                                                                                                              |
| Low Voltage                              | 2.25 V                                                                                                                                                                                                                                                             |
| High Voltage                             | 3.2 V                                                                                                                                                                                                                                                              |
| Normal Temperature                       | 20.0 °C                                                                                                                                                                                                                                                            |
| Low Temperature                          | -20.0 °C                                                                                                                                                                                                                                                           |
| High Temperature                         | +60.0 °C                                                                                                                                                                                                                                                           |
| Antenna type                             | Integrated monopole antenna                                                                                                                                                                                                                                        |
| UWB technology                           | Impulse radio                                                                                                                                                                                                                                                      |
| Modulation                               | Frequency Shift Keying (FSK) +/- 125 MHz                                                                                                                                                                                                                           |
| Modulation Parameters                    | UWB pulse length: appr. 4.5 ns<br>UWB pulse repetition: appr. 250 ns<br>Symbol 1: FSK-Low (fc – 125 MHz)<br>Symbol 0: FSK-High (fc + 125 MHz)<br>16 pulses form a data bit<br>Bit "0": 1 1 0 1 0 0 1 1 0 0 1 0 1 1 0 0<br>Bit "1": 0 0 1 0 1 1 0 0 1 1 0 1 0 0 1 1 |
| Occupied bandwidth                       | 500 MHz                                                                                                                                                                                                                                                            |
| Highest internal frequency               | 7560 MHz                                                                                                                                                                                                                                                           |
| Ports                                    | Enclosure                                                                                                                                                                                                                                                          |
| Special software used for testing        | Special test software based on series SW version 5                                                                                                                                                                                                                 |

**The main components of the EUT are listed and described in chapter 3.2 EUT Main components.**

### 3.2 EUT MAIN COMPONENTS

| Sample Name      | Sample Code                                        | Description            |
|------------------|----------------------------------------------------|------------------------|
| EUT A            | DE1232006aa12                                      | Radiated UWB TX sample |
| Sample Parameter | Value                                              |                        |
| HW Version       | 16                                                 |                        |
| SW Version       | Special test software based on series SW version 5 |                        |
| Serial No.       | -                                                  |                        |
| Comment          |                                                    |                        |

| Sample Name      | Sample Code                                        | Description            |
|------------------|----------------------------------------------------|------------------------|
| EUT B            | DE1232004aa14                                      | Radiated UWB TX sample |
| Sample Parameter | Value                                              |                        |
| HW Version       | 16                                                 |                        |
| SW Version       | Special test software based on series SW version 5 |                        |
| Serial No.       | -                                                  |                        |
| Comment          | For TX-timing test; FS19                           |                        |

| Sample Name      | Sample Code                                                                   | Description        |
|------------------|-------------------------------------------------------------------------------|--------------------|
| EUT C            | DE1232004aa15                                                                 | Radiated TX sample |
| Sample Parameter | Value                                                                         |                    |
| HW Version       | 16                                                                            |                    |
| SW Version       | SW version 5                                                                  |                    |
| Serial No.       | -                                                                             |                    |
| Comment          | For associated receiver tests<br>WOB [Wake Up Pattern] known to the car; FS19 |                    |

| Sample Name      | Sample Code                                                                           | Description        |
|------------------|---------------------------------------------------------------------------------------|--------------------|
| EUT D            | DE1232004aa07                                                                         | Radiated TX sample |
| Sample Parameter | Value                                                                                 |                    |
| HW Version       | 16                                                                                    |                    |
| SW Version       | SW version 5                                                                          |                    |
| Serial No.       | -                                                                                     |                    |
| Comment          | For not associated receiver tests<br>WOB [Wake Up Pattern] not known to the car; FS19 |                    |

| Sample Name      | Sample Code                                              | Description             |
|------------------|----------------------------------------------------------|-------------------------|
| EUT E            | DE1232006aa13                                            | Conducted UWB TX sample |
| Sample Parameter | Value                                                    |                         |
| HW Version       | 16                                                       |                         |
| SW Version       | Special test software based on series SW version 5       |                         |
| Serial No.       | -                                                        |                         |
| Comment          | UWB antenna replaced by a short cable with SMA connector |                         |

| Sample Name      | Sample Code                                           | Description        |
|------------------|-------------------------------------------------------|--------------------|
| EUT F            | DE1232006aa15                                         | Radiated TX sample |
| Sample Parameter | Value                                                 |                    |
| HW Version       | 16                                                    |                    |
| SW Version       | SW version 5                                          |                    |
| Serial No.       | -                                                     |                    |
| Comment          | For transmission time tests, only PCB without housing |                    |

NOTE: The short description is used to simplify the identification of the EUT in this test report.

### 3.3 ANCILLARY EQUIPMENT

For the purposes of this test report, ancillary equipment is defined as equipment which is used in conjunction with the EUT to provide operational and control features to the EUT. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Ancillary Equipment can influence the test results.

| Device | Details<br>(Manufacturer, Type Model, OUT Code) | Description |
|--------|-------------------------------------------------|-------------|
| -      | -                                               | -           |

### 3.4 AUXILIARY EQUIPMENT

For the purposes of this test report, auxiliary equipment is defined as equipment which is used temporarily to enable operational and control features especially used for the tests of the EUT which is not used during normal operation or equipment that is used during the tests in combination with the EUT but is not subject of this test report. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Auxiliary Equipment can influence the test results.

| Device | Details<br>(Manufacturer, HW, SW, S/N)                                                                                                                                                                                                                                                                                                                                                                                        | Description                                          |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| AUX1   | <ul style="list-style-type: none"> <li>Door proximity sensor</li> <li>013854 - LF KESSY IO box (incl. LF antennas)</li> <li>RSB19 -UWB ranging device</li> <li>BCM - Body Controller Module (contains a 434 UHF transceiver), connected via CAN-bus</li> <li>The CAR network is simulated by a VECTOR CAN simulation</li> </ul>                                                                                               | System test check setup for Associated Receiver test |
| AUX2   | <ul style="list-style-type: none"> <li>PC (special program running car simulation)</li> <li>RSB19 -UWB ranging device</li> <li>CAN-Bus Controller</li> <li>KTB 3.0 with UHF Antennas with an external LF-Antenna (to control LF and UHF communication)</li> <li>Arduino Board with circuit to deactivate the UWB receiver inside the RSB19. (this is triggered by the enable line of DC-DC Converter in the FS197)</li> </ul> |                                                      |

### 3.5 EUT SETUPS

This chapter describes the combination of EUTs and equipment used for testing. The rationale for selecting the EUTs, ancillary and auxiliary equipment and interconnecting cables, is to test a representative configuration meeting the requirements of the referenced standards.

| Setup    | Combination of EUTs | Description and Rationale           |
|----------|---------------------|-------------------------------------|
| S01_AA10 | EUT A               | radiated setup                      |
| S01_AA14 | EUT B               | radiated setup, TX-timing           |
| S01_SYS1 | EUT C, AUX1         | radiated setup, associated receiver |
| S01_SYS2 | EUT D, AUX1         | radiated setup, associated receiver |
| S01_AA13 | EUT E               | conducted setup                     |
| S01_SYS3 | EUT F, AUX2         | radiated setup, transmission time   |

### 3.6 OPERATING MODES

This chapter describes the operating modes of the EUTs used for testing.

Series like UWB telegrams with dummy data (e.g. 0xCAFECAFECAFECAFE & postamble) with appr. 1.52 ms repetition rate

#### 3.6.1 TEST CHANNELS

|                                                                | low  | mid  | high |
|----------------------------------------------------------------|------|------|------|
| <b>Declared Single Operating Frequencies for testing [MHz]</b> | 6520 | 7040 | 7560 |

### 3.7 PRODUCT LABELLING

#### 3.7.1 FCC ID LABEL

Please refer to the documentation of the applicant.

#### 3.7.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

## 4 TEST RESULTS

### 4.1 -10 dB BANDWIDTH – 15.503(d)

Standard **FCC Part 15 Subpart F**

**The test was performed according to:**  
ANSI C63.10

**Definition:**

The Equipment Under Test (EUT) was set up to perform the occupied bandwidth measurements.

The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical.

The results recorded were measured with the modulation which produce the worst-case (biggest) emission bandwidth.

**Test Procedure:**

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.

The measurement was performed with one height (1.5 m) of the receiving antenna.

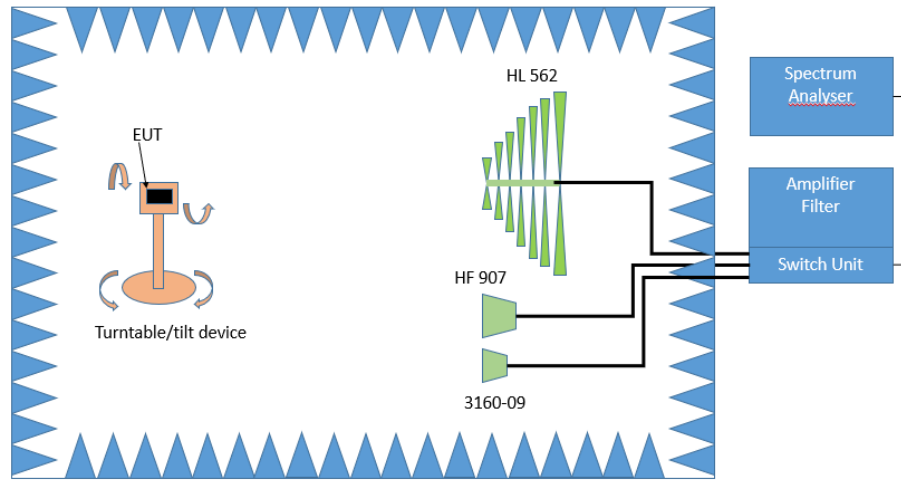
The measurement distance was 3m.

A search for the direction of maximum output power level is not performed because this is a relative measurement.

The test procedure for “Evaluation of -10 dB bandwidth” of the ANSI C63.10, Chapter 10.1 was used with the following Spectrum Analyzer settings:

- Resolution Bandwidth (RBW): 1 MHz
- Video Bandwidth (VBW): 3 MHz
- Center Frequency: Nominal channel center frequency
- Span: 1 GHz
- Sweptime: 1s
- Sweep points: 1001
- Sweeps: until trace stabilizes
- Trace: Maxhold
- Detector: Peak

The Test was performed radiated in a Fully Anechoic Chamber in the following setup:



Test Setup; Spurious Emission Radiated (FAC), 30 MHz -26.5 GHz

#### 4.1.1 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart F, §15.503 (d)

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

RSS-220, 2.

A UWB device is an intentional radiator that has either a -10 dB bandwidth of at least 500 MHz or a -10 dB fractional bandwidth greater than 0.2.

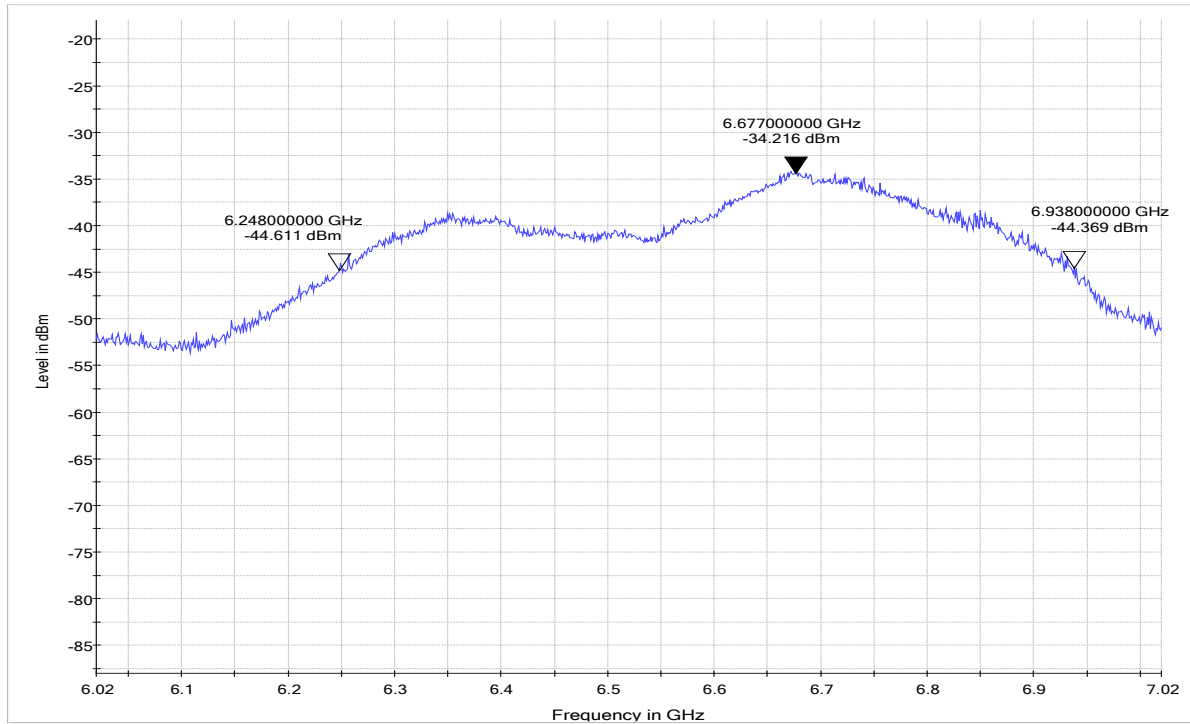
#### 4.1.2 TEST PROTOCOL

**Ambient temperature:** 24 °C  
**Air Pressure:** 1019 hPa  
**Humidity:** 31 %

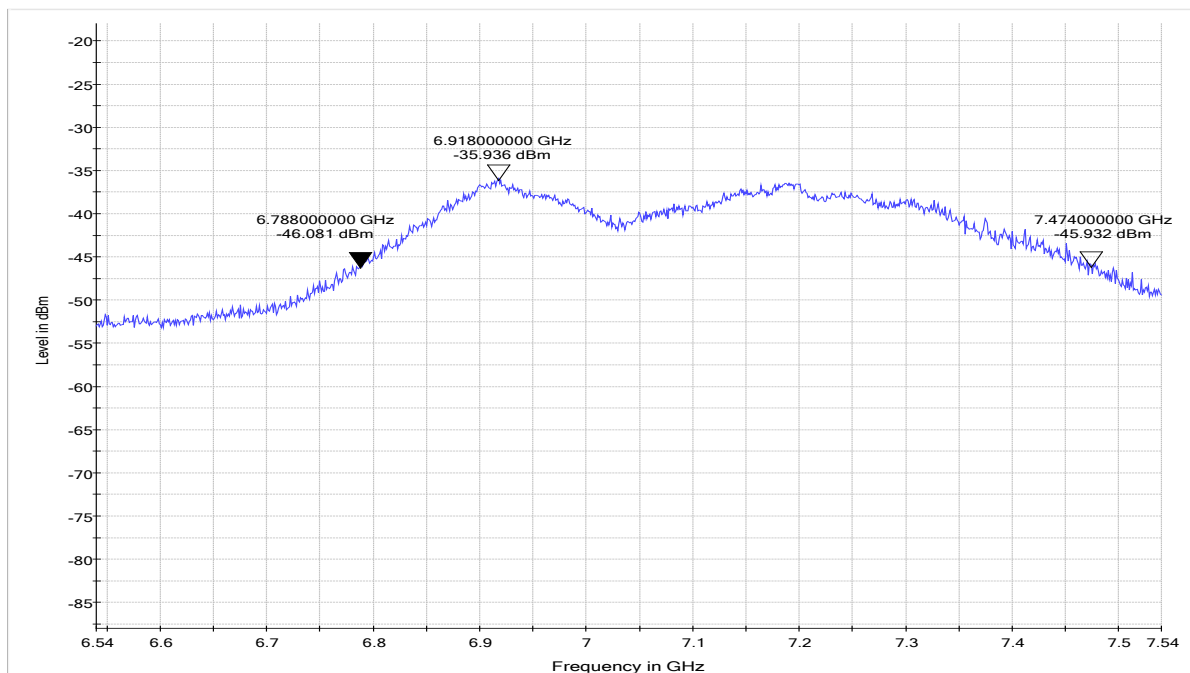
| Operating Band: 3100 - 10600 MHz |                                 |                                 |                        |                           |                          |                                    |                                          |
|----------------------------------|---------------------------------|---------------------------------|------------------------|---------------------------|--------------------------|------------------------------------|------------------------------------------|
| Channel                          | Lower -10 dB Frequency fL [MHz] | Upper -10 dB Frequency fH [MHz] | Max Frequency fM [MHz] | Center Frequency fC [MHz] | Occupied Bandwidth [MHz] | Minimum Occupied Bandwidth h [MHz] | Occupied Bandwidth Margin to Limit [MHz] |
| Low                              | 6248.00                         | 6938.00                         | 6677.00                | 6593.0                    | 690.0                    | 500.0                              | 190.0                                    |
| Mid                              | 6788.00                         | 7474.00                         | 6918.00                | 7131.0                    | 686.0                    | 500.0                              | 186.0                                    |
| High                             | 7287.00                         | 7935.00                         | 7740.00                | 7611.0                    | 648.0                    | 500.0                              | 148.0                                    |

#### 4.1.3 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

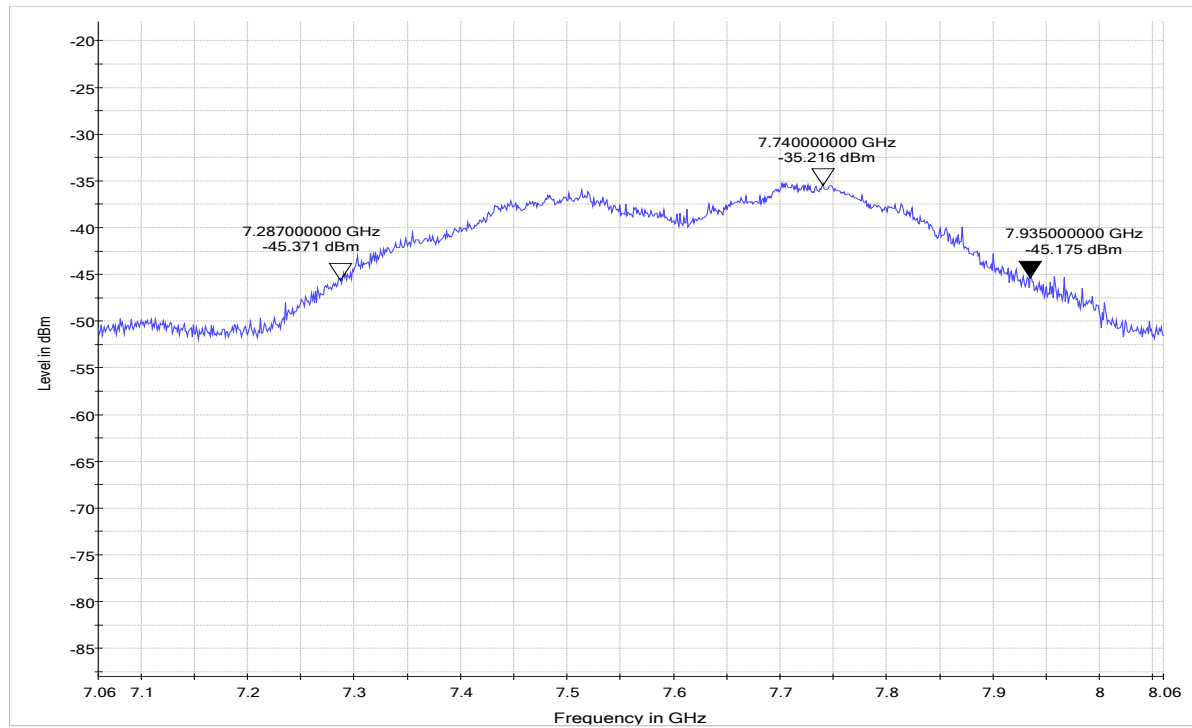
Measurement method = radiated, Operating band = 3100 – 10600 MHz, Channel = low (S01\_AA10)



Measurement method = radiated, Operating band = 3100 – 10600 MHz, Channel = mid (S01\_AA10)



Measurement method = radiated, Operating band = 3100 – 10600 MHz, Channel = high  
(S01\_AA10)



TEST EQUIPMENT USED:  
- Radiated Emissions

## 4.2 -10 dB BANDWIDTH -15.519 (b)

Standard **FCC Part 15 Subpart F**

**The test was performed according to:**  
ANSI C63.10

### Definition:

The Equipment Under Test (EUT) was set up to perform the occupied bandwidth measurements.

The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical.

The results recorded were measured with the modulation which produce the worst-case (biggest) emission bandwidth.

### Test Procedure:

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.

The measurement was performed with one height (1.5 m) of the receiving antenna.

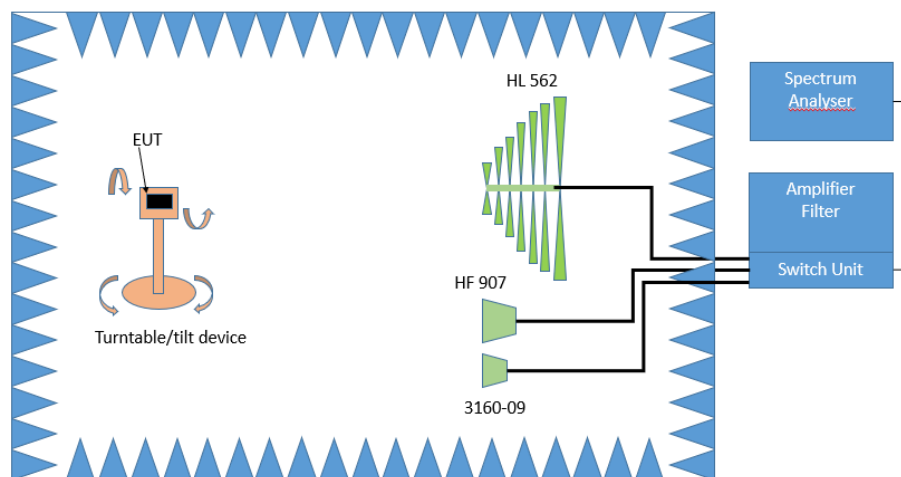
The measurement distance was 3m.

A search for the direction of maximum output power level is not performed because this is a relative measurement.

The test procedure for "Evaluation of -10 dB bandwidth" of the ANSI C63.10, Chapter 10.1 was used with the following Spectrum Analyzer settings:

- Resolution Bandwidth (RBW): 1 MHz
- Video Bandwidth (VBW): 3 MHz
- Center Frequency: Nominal channel center frequency
- Span: 1 GHz
- Sweptime: 1s
- Sweep points: 1001
- Sweeps: until trace stabilizes
- Trace: Maxhold
- Detector: Peak

The Test was performed radiated in a Fully Anechoic Chamber in the following setup:



Test Setup; Spurious Emission Radiated (FAC), 30 MHz -26.5 GHz

#### 4.2.1 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart F, §15.519 (b)

The UWB bandwidth of a device operating under the provisions of this section must be contained between 3100 MHz and 10600 MHz.

RSS-220, 5.1 (a)

The -10 dB bandwidth of the device shall be totally contained in the band 3.1-10.6 GHz.

#### 4.2.2 TEST PROTOCOL

**Ambient**

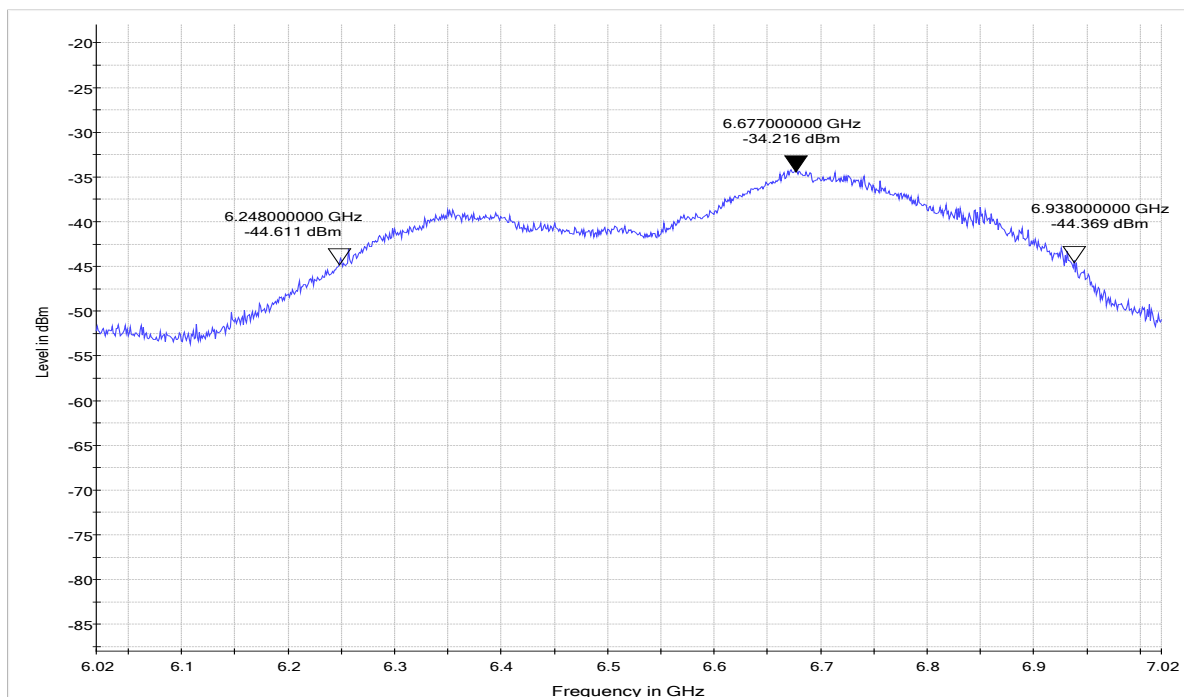
**temperature:** 24 °C

**Air Pressure:** 1019 hPa

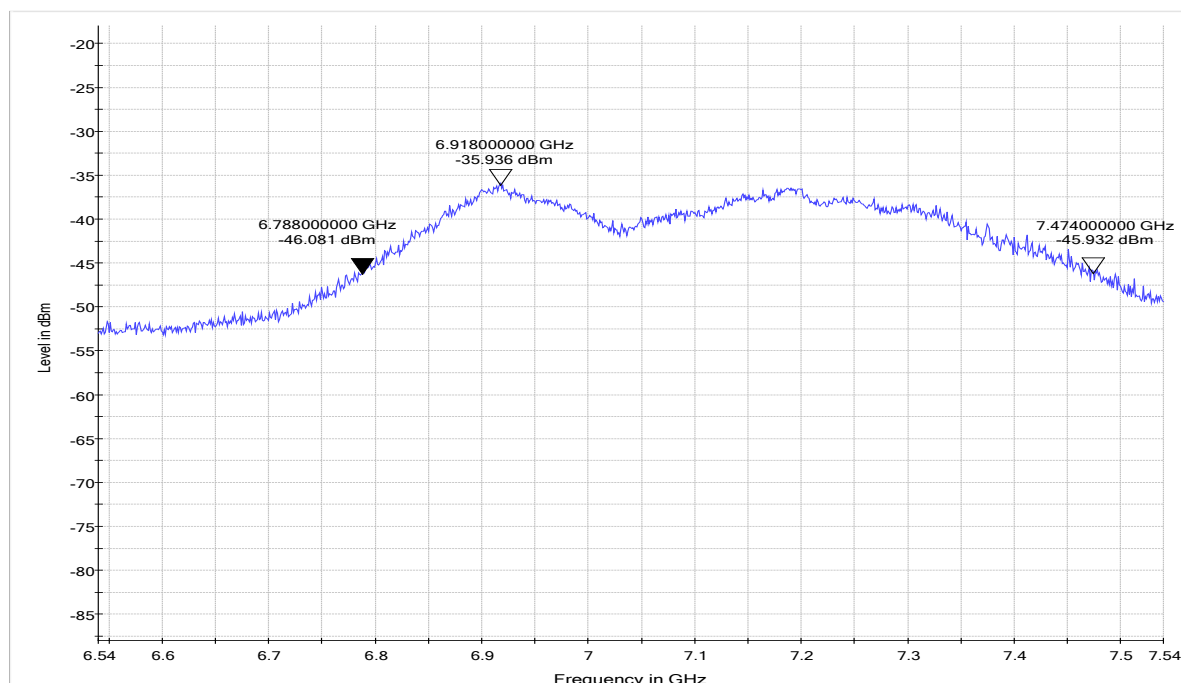
**Humidity:** 31 %

| Operating Band: 3100 - 10600 MHz |                                       |                                       |                                |                                |                                      |                                      |
|----------------------------------|---------------------------------------|---------------------------------------|--------------------------------|--------------------------------|--------------------------------------|--------------------------------------|
| Channel                          | Lower<br>-10 dB<br>Frequency<br>[MHz] | Upper<br>-10 dB<br>Frequency<br>[MHz] | Lower<br>Band<br>Edge<br>[MHz] | Upper<br>Band<br>Edge<br>[MHz] | Margin to<br>Lower<br>Limit<br>[MHz] | Margin to<br>Upper<br>Limit<br>[MHz] |
| Low                              | 6248.00                               | 6938.00                               | 3100.00                        | 10600.00                       | 3148.00                              | 3662.00                              |
| Mid                              | 6788.00                               | 7474.00                               | 3100.00                        | 10600.00                       | 3688.00                              | 3126.00                              |
| High                             | 7287.00                               | 7935.00                               | 3100.00                        | 10600.00                       | 4187.00                              | 2665.00                              |

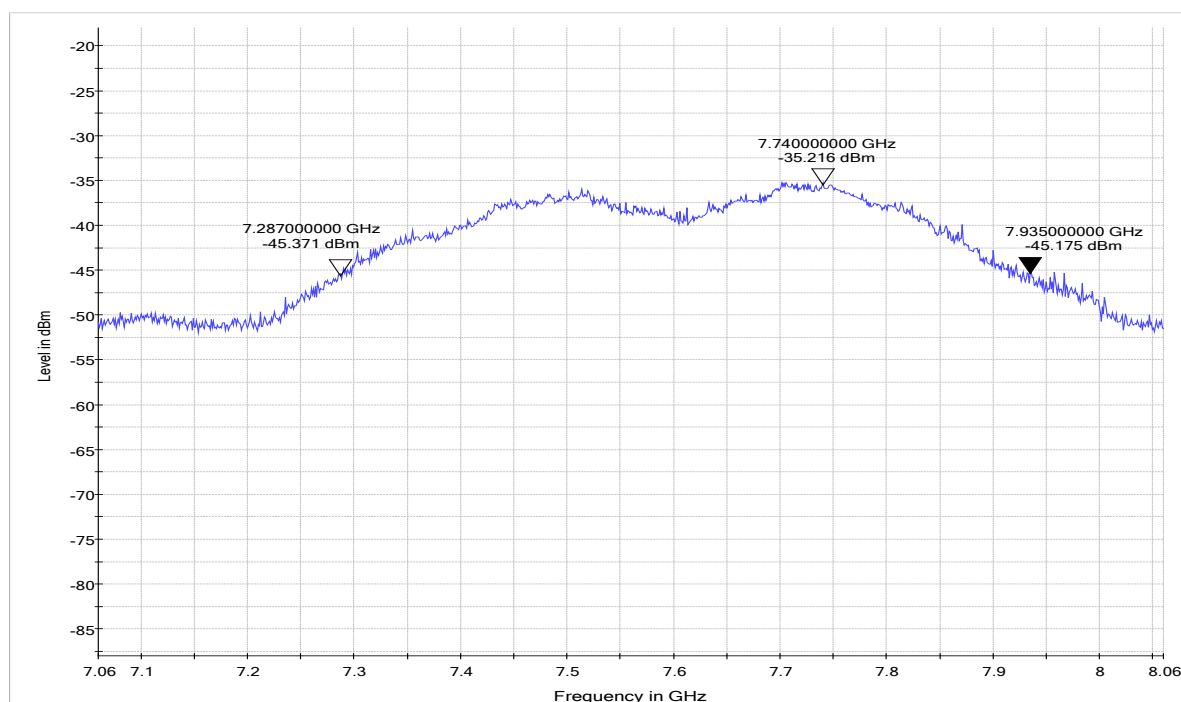
#### 4.2.3 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE") (S01\_AA10)



Measurement method = radiated, Operating band = 3100 – 10600 MHz, Channel = mid (S01\_AA10)



Measurement method = radiated, Operating band = 3100 – 10600 MHz, Channel = high (S01\_AA10)



TEST EQUIPMENT USED:  
- Radiated Emissions

### 4.3 PEAK EMISSION – 15.519(e)

Standard **FCC Part 15 Subpart F**

**The test was performed according to:**  
ANSI C63.10

**Definition:**

The maximum peak power specified as e.i.r.p. contained within a 50 MHz bandwidth at the frequency at which the highest mean radiated power occurs, radiated in the direction of the maximum level under the specified conditions of measurement.

**Test Procedure:**

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.

All steps were performed with one height (1.5 m) of the receiving antenna only.

The measurement distance for all steps was 3m.

**Step 1: Preliminary scan**

This is a preliminary test to identify the direction of maximum output power level of the EUT.

Spectrum analyser settings for step 1:

- Resolution Bandwidth (RBW): 1 MHz
- Video Bandwidth (VBW): 3 MHz
- Detector: RMS
- Center Frequency: Nominal channel center frequency
- Span: 1 GHz
- Sweptime: 1s
- Sweep points: 1001
- Sweeps: 10
- Trace: Maxhold

Turn table and antenna settings

- Turntable angle range:  $-180^{\circ}$  to  $90^{\circ}$
- Turntable step size (azimuth):  $45^{\circ}$
- Elevation angle range:  $0^{\circ}$  -  $90^{\circ}$
- Elevation step size:  $90^{\circ}$
- Antenna polarisation: Horizontal + Vertical

**Step 2: Adjustment measurement**

In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.

For the frequency with the highest power, the turntable azimuth and EUT elevation will be adjusted. The turntable azimuth will slowly vary by  $\pm 22.5^{\circ}$ . The elevation angle will slowly vary by  $\pm 45^{\circ}$ . During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the elevation angle will also slowly vary by  $\pm 22.5^{\circ}$  around the elevation angle determined in step one. During this action, the value of emission is also continuously measured. The elevation angle of the highest emission will also be recorded and adjusted.

- Measured frequencies: in step 1 determined frequencies
- Resolution Bandwidth (RBW): 1 MHz
- Video Bandwidth (VBW): 3 MHz
- Detector: RMS
- Sweep time: 100 ms
- Turntable angle range:  $\pm 22.5^\circ$  around the determined value of step 1
- EUT elevation angle:  $\pm 45^\circ$  around the determined value of step 1
- Antenna Polarisation: max. value determined in step 1

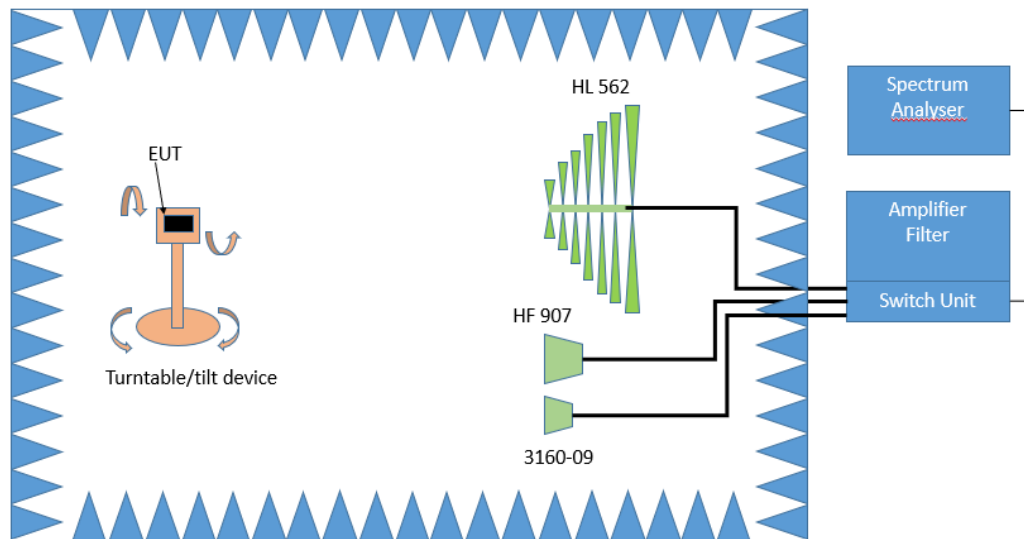
**Step 3: Final measurement with the following analyser settings**

Analyzer settings:

- Resolution Bandwidth (RBW): 50 MHz
- Video Bandwidth (VBW): 50 MHz
- Center Frequency: Nominal channel center frequency
- Span: 1 GHz
- Sweptime: 1s
- Sweep points: 1001
- Trace: Maxhold
- Sweeps: until trace stabilizes
- Sweptime: 1 s
- Detector: Peak

After the measurement, a plot will be generated which contains a diagram with the results of the final measurement. A marker shows the highest emission.

The radiated test was performed with the following setup:



Test Setup; Spurious Emission Radiated (FAC), 30 MHz -26.5 GHz

#### 4.3.1 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart F, §15.519 (e)

There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs,  $f_M$ .

That limit is 0 dBm EIRP.

RSS-220, 5.3.1 (g)

The peak level of the transmissions shall not exceed the peak equivalent of the average limit contained within any 50 MHz bandwidth, as defined in section 4 of the Annex.

RSS-220, Annex 4 (c)

Peak measurements shall be made in addition to average measurements. Transmissions shall not exceed 0 dBm e.i.r.p. in any 50 MHz bandwidth when the average limit is -41.3 dBm/MHz.

#### 4.3.2 TEST PROTOCOL

**Ambient**

**temperature:** 24 °C

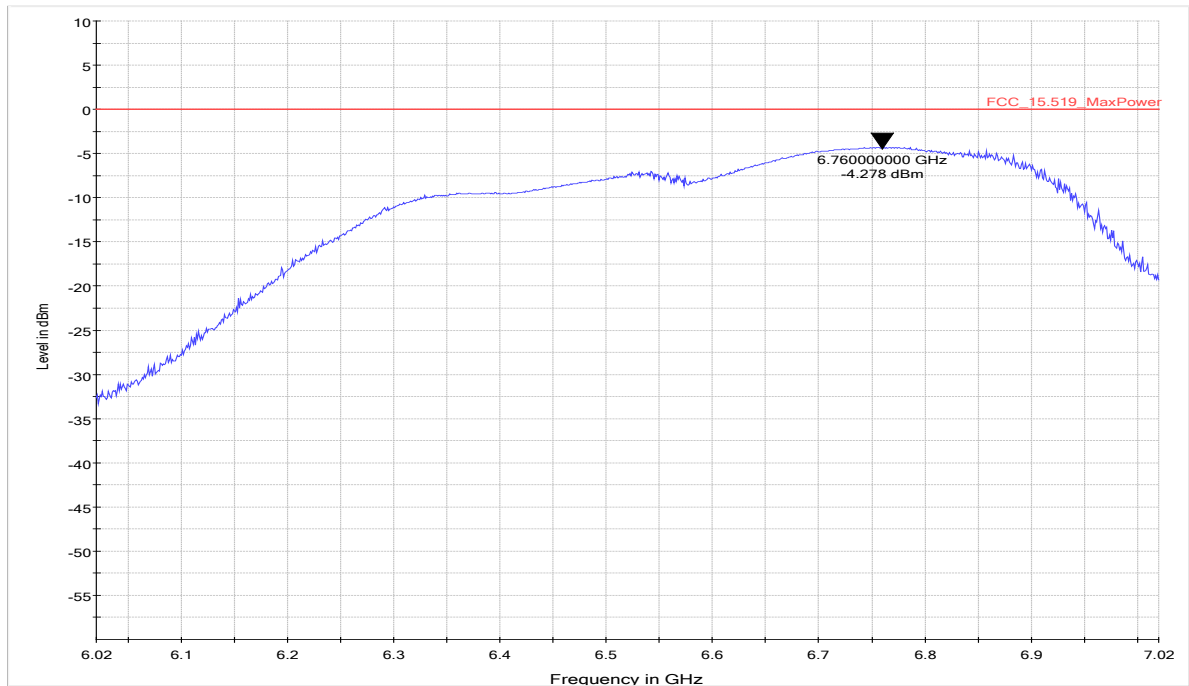
**Air Pressure:** 1019 hPa

**Humidity:** 31 %

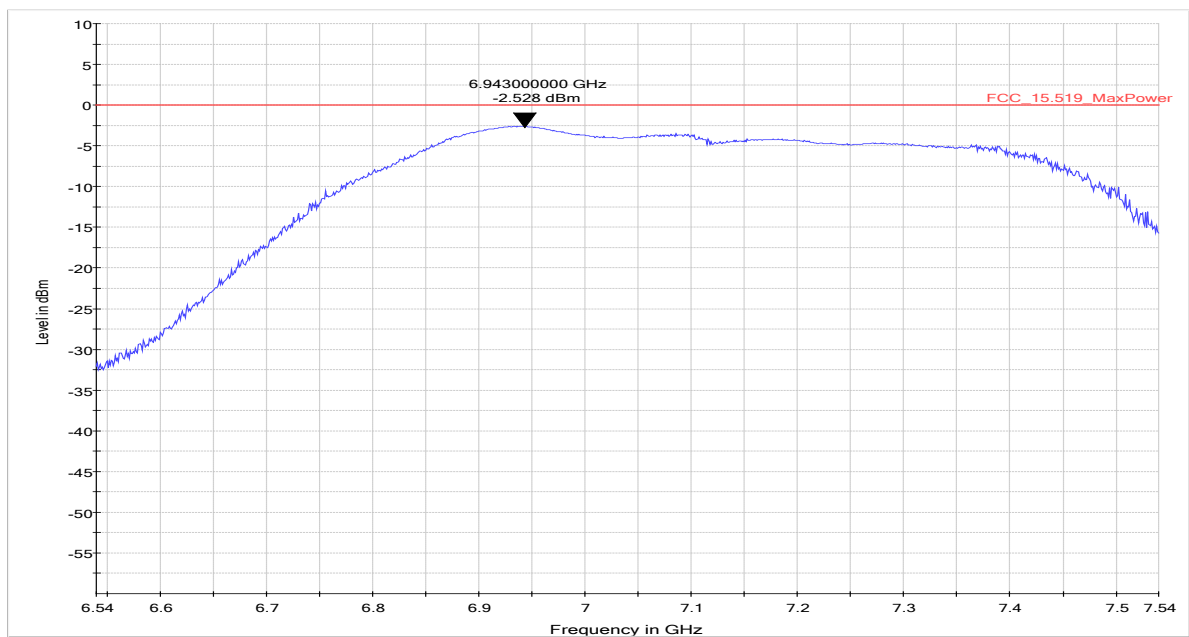
| Operating Band: 3100 - 10600 MHz |                                   |                                       |                  |                             |
|----------------------------------|-----------------------------------|---------------------------------------|------------------|-----------------------------|
| Operating Frequency              | Highest Peak Emission Power [dBm] | Highest Peak Emission Frequency [MHz] | Peak Limit [dBm] | Margin to Power Limit [dBm] |
| Low                              | -4.3                              | 6760.00                               | 0.0              | 4.3                         |
| Mid                              | -2.5                              | 6943.00                               | 0.0              | 2.5                         |
| High                             | -5.3                              | 7759.00                               | 0.0              | 5.3                         |

#### 4.3.3 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

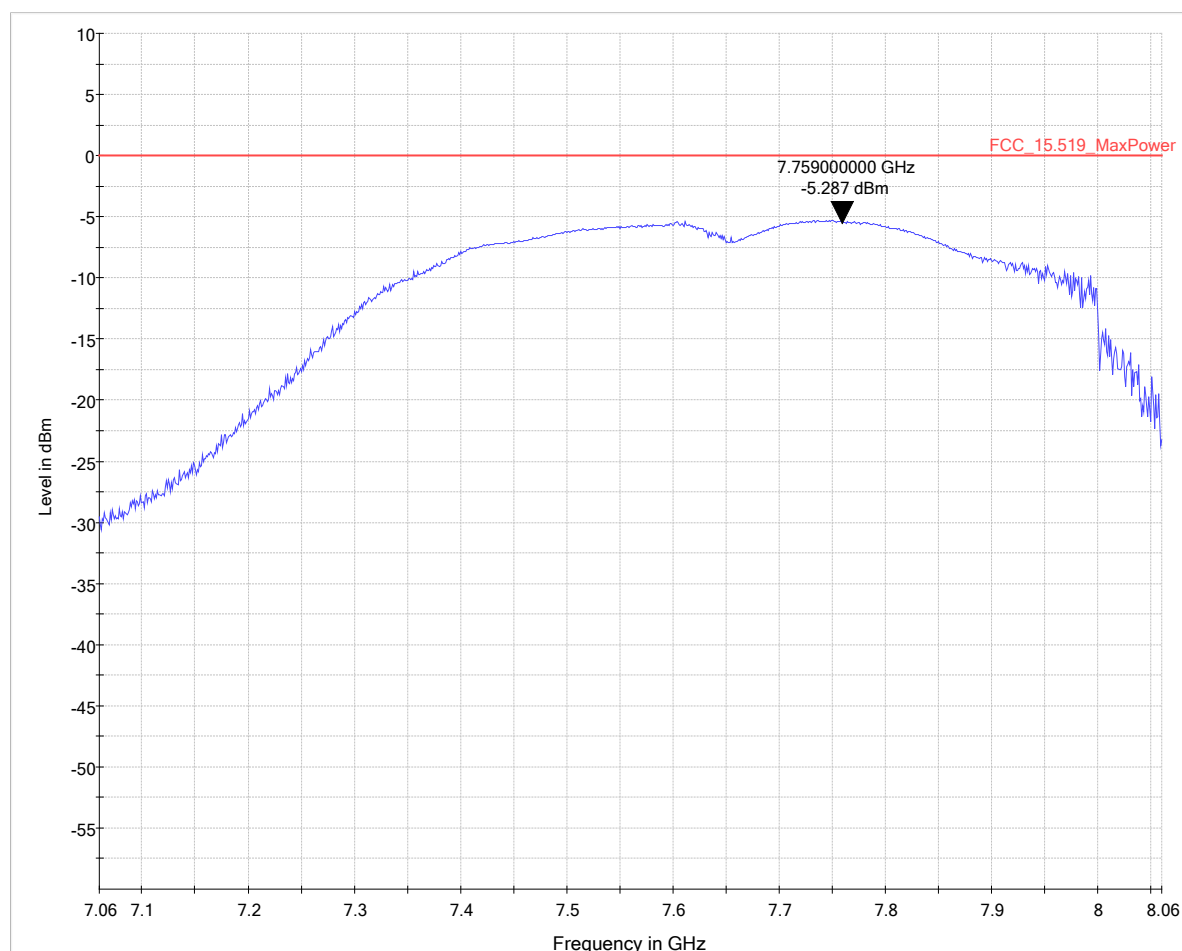
Measurement method = radiated, Operating band = 3100 – 10600 MHz, Channel = low (S01\_AA10)



Measurement method = radiated, Operating band = 3100 – 10600 MHz, Channel = mid (S01\_AA10)



Measurement method = radiated, Operating band = 3100 – 10600 MHz, Channel = high  
(S01\_AA10)



TEST EQUIPMENT USED:  
- Radiated Emissions

#### 4.4 PEAK EMISSION – 15.521(e)

Standard **FCC Part 15 Subpart F**

**The test was performed according to:**  
ANSI C63.10

**Definition:**

The maximum peak power specified as e.i.r.p. contained within a 50 MHz bandwidth at the frequency at which the highest mean radiated power occurs, radiated in the direction of the maximum level under the specified conditions of measurement.

**Test Procedure:**

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.

All steps were performed with one height (1.5 m) of the receiving antenna only.

The measurement distance for all steps was 3m.

**Step 1: Preliminary scan**

This is a preliminary test to identify the direction of maximum output power level of the EUT.

Spectrum analyser settings for step 1:

- Resolution Bandwidth (RBW): 1 MHz
- Video Bandwidth (VBW): 3 MHz
- Detector: RMS
- Center Frequency: Nominal channel center frequency
- Span: 1 GHz
- Sweptime: 1s
- Sweep points: 1001
- Sweeps: 10
- Trace: Maxhold

Turn table and antenna settings

- Turntable angle range:  $-180^{\circ}$  to  $90^{\circ}$
- Turntable step size (azimuth):  $45^{\circ}$
- Elevation angle range:  $0^{\circ}$  -  $90^{\circ}$
- Elevation step size:  $90^{\circ}$
- Antenna polarisation: Horizontal + Vertical

**Step 2: Adjustment measurement**

In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.

For the frequency with the highest power, the turntable azimuth and EUT elevation will be adjusted. The turntable azimuth will slowly vary by  $\pm 22.5^{\circ}$ . The elevation angle will slowly vary by  $\pm 45^{\circ}$ . During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the elevation angle will also slowly vary by  $\pm 22.5^{\circ}$  around the elevation angle determined in step one. During this action, the value of emission is also continuously measured. The elevation angle of the highest emission will also be recorded and adjusted.

- Measured frequencies: in step 1 determined frequencies
- Resolution Bandwidth (RBW): 1 MHz
- Video Bandwidth (VBW): 3 MHz
- Detector: RMS
- Sweep time: 100 ms
- Turntable angle range:  $\pm 22.5^\circ$  around the determined value of step 1
- EUT elevation angle:  $\pm 45^\circ$  around the determined value of step 1
- Antenna Polarisation: max. value determined in step 1

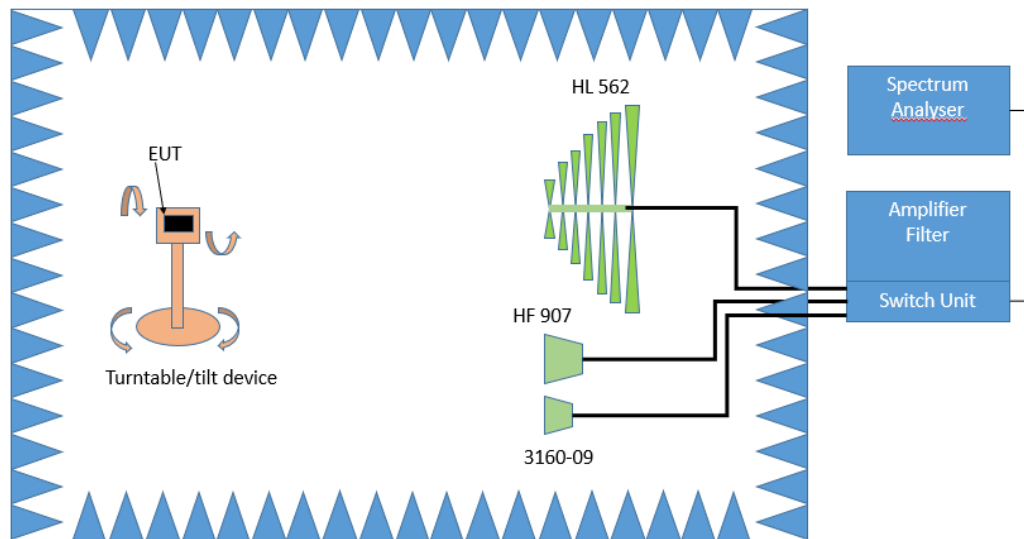
**Step 3: Final measurement with the following analyser settings**

Analyzer settings:

- Resolution Bandwidth (RBW): 50 MHz
- Video Bandwidth (VBW): 50 MHz
- Center Frequency: Nominal channel center frequency
- Span: 1 GHz
- Sweeptime: 1s
- Sweep points: 1001
- Trace: Maxhold
- Sweeps: until trace stabilizes
- Sweeptime: 1 s
- Detector: Peak

After the measurement, a plot will be generated which contains a diagram with the results of the final measurement. A marker shows the highest emission.

The radiated test was performed with the following setup:



Test Setup; Spurious Emission Radiated (FAC), 30 MHz -26.5 GHz

#### 4.4.1 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart F, §15.221 (e)

The frequency at which the highest radiated emission occurs,  $f_m$ , must be contained within the UWB bandwidth.

#### 4.4.2 TEST PROTOCOL

**Ambient**

**temperature:** 24 °C

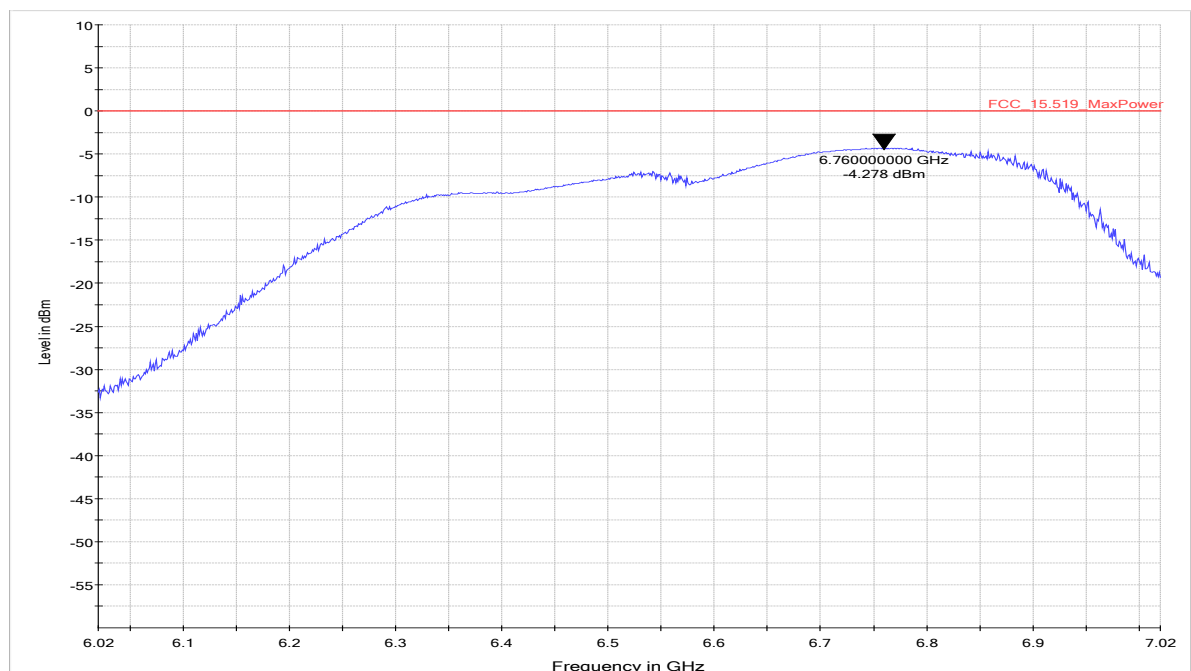
**Air Pressure:** 1019 hPa

**Humidity:** 31 %

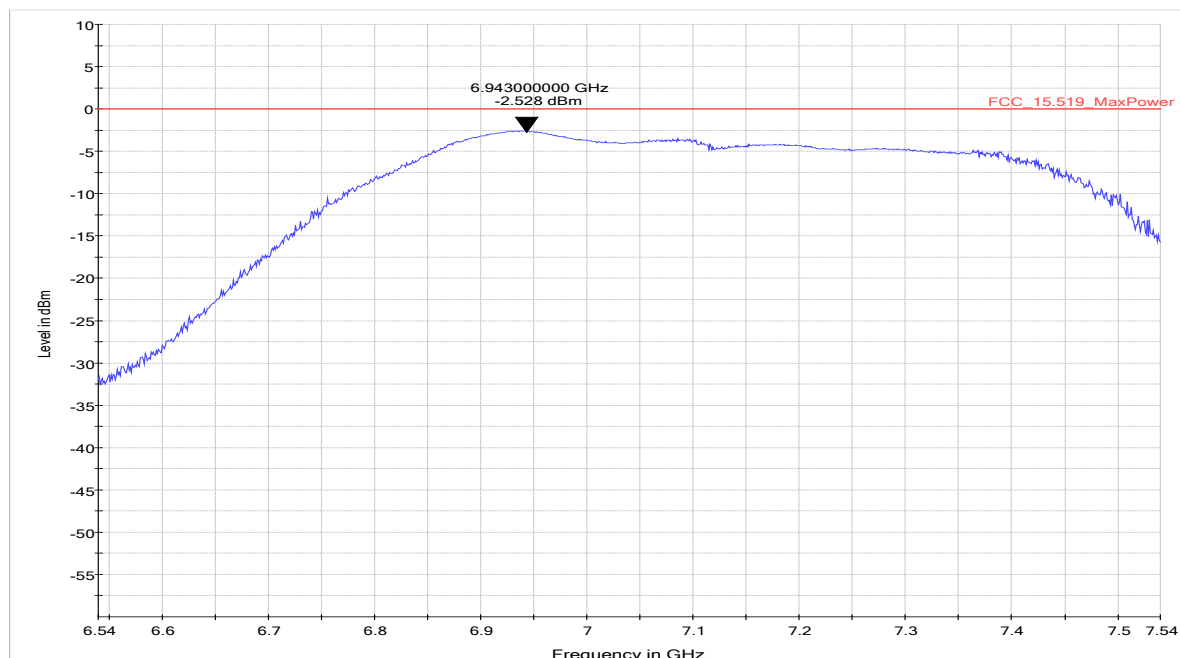
| Operating Band: 3100 - 10600 MHz |                                                |                                             |                                                    |                                    |
|----------------------------------|------------------------------------------------|---------------------------------------------|----------------------------------------------------|------------------------------------|
| Channel                          | Lower<br>-10 dB<br>Frequency<br>$f_L$<br>[MHz] | Upper<br>-10 dB<br>Frequency $f_H$<br>[MHz] | Highest<br>Emission<br>Frequency<br>$F_m$<br>[MHz] | Fmax<br>within<br>UWB<br>Bandwidth |
| Low                              | 6248.00                                        | 6938.00                                     | 6760.00                                            | YES                                |
| Mid                              | 6788.00                                        | 7474.00                                     | 6943.00                                            | YES                                |
| High                             | 7287.00                                        | 7935.00                                     | 7759.00                                            | YES                                |

#### 4.4.3 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

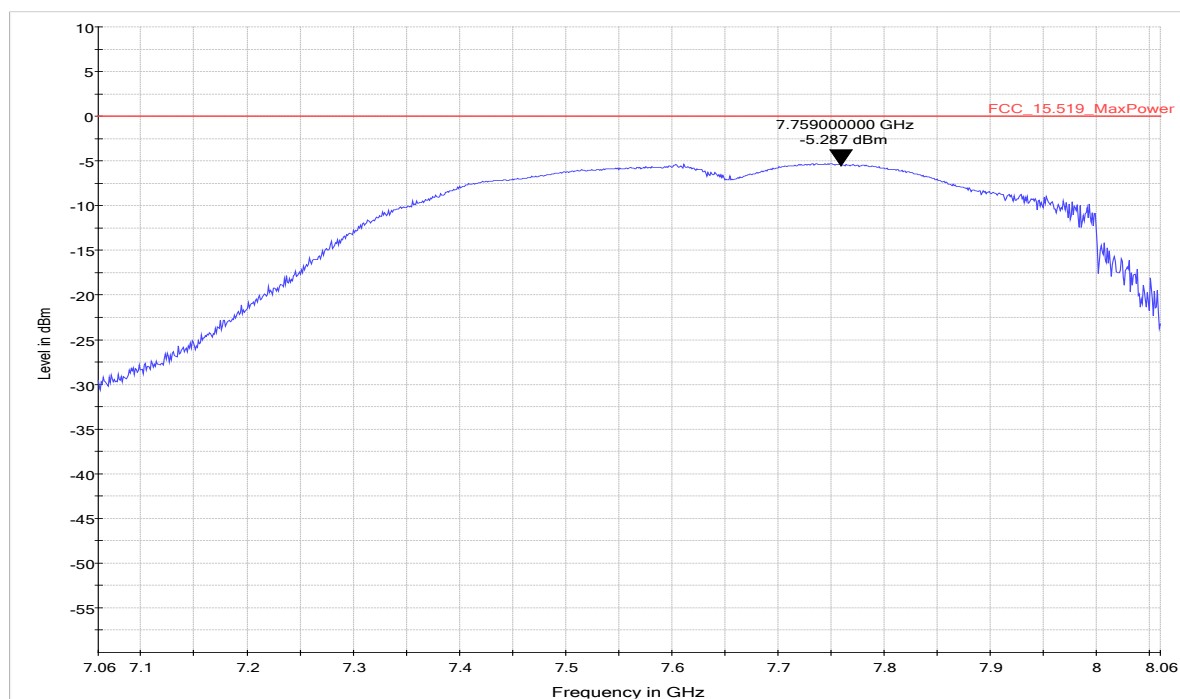
Measurement method = radiated, Operating band = 3100 – 10600 MHz, Channel = low (S01\_AA10)



Measurement method = radiated, Operating band = 3100 – 10600 MHz, Channel = mid (S01\_AA10)



Measurement method = radiated, Operating band = 3100 – 10600 MHz, Channel = high (S01\_AA10)



TEST EQUIPMENT USED:  
- Radiated Emissions

## 4.5 RADIATED EMISSIONS

Standard      **FCC Part 15 Subpart F**  
                  **FCC Part 15 Subpart C**

**The test was performed according to:**  
ANSI C63.10

### 4.5.1 TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m<sup>2</sup> in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.

The measurement procedure is implemented into the EMI test software EMC32 from R&S. Exploratory tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is also performed at 3 axes. A pre-check is performed while the EUT is powered from a DC power source.

#### 1. Measurement up to 30 MHz

The Loop antenna HFH2-Z2 is used.

##### Step 1: pre measurement

Settings for step 1:

- Anechoic chamber
- Antenna distance: 3 m
- Antenna height: 1 m
- Detector: Peak-Maxhold
- Frequency range: 0.009 - 0.15 MHz and 0.15 – 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz
- IF-Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

##### Step 2: final measurement

For the relevant emissions determined in step 1, an additional measurement with the following settings will be performed. Intention of this step is to find the maximum emission level.

- Detector: Quasi-Peak (9 kHz – 150 kHz, Peak / Average 150 kHz- 30 MHz)
- Frequency range: 0.009 – 30 MHz
- Frequency steps: measurement at frequencies detected in step 1
- IF-Bandwidth: 0.2 - 10 kHz
- Measuring time / Frequency step: 1 s

#### 2. Measurement above 30 MHz and up to 960 MHz

##### Step 1: Preliminary scan

This is a preliminary test to identify the highest amplitudes relative to the limit.

Settings for step 1:

- Measurement distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)
- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF-Bandwidth: 120 kHz

- Measuring time / Frequency step: 100 ms
- Turntable angle range:  $-180^{\circ}$  to  $90^{\circ}$
- Turntable step size:  $90^{\circ}$
- Height variation range: 1 – 3 m
- Height variation step size: 2 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

#### **Step 2: Adjustment measurement**

In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.

For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will slowly vary by  $\pm 45^{\circ}$  around this value. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the antenna height will also slowly vary by  $\pm 100$  cm around the antenna height determined. During this action, the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.

- Detector: Peak – Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range:  $\pm 45^{\circ}$  around the determined value
- Height variation range:  $\pm 100$  cm around the determined value
- Antenna Polarisation: max. value determined in step 1

#### **Step 3: Final measurement with QP detector**

With the settings determined in step 2, the final measurement will be performed:

EMI receiver settings for step 3:

- Detector: Quasi-Peak ( $< 1$  GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

### **3. Measurement 960 MHz – 18 GHz**

The following modifications apply to the measurement procedure for the frequency range 960 MHz – 18 GHz:

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.

All steps were performed with one height (1.5 m) of the receiving antenna only.

The following spectrum analyser settings are used for all steps:

- Measurement distance: 1 m
- Detector: RMS
- RBW: 1 MHz
- VBW: 3 MHz
- Measuring time: 1 ms / Sweep point
- Sweep Points: 1 / MHz [Span]

### Step 1: Preliminary scan

Settings for step 1:

- Turntable angle range:  $-180^{\circ}$  to  $90^{\circ}$
- Turntable step size:  $45^{\circ}$
- Elevation step size:  $90^{\circ}$
- Polarisation: Horizontal + Vertical

### Step 2: Adjustment measurement

In this step the accuracy of the turntable azimuth elevation will be improved. This is necessary to find out the maximum value of every frequency.

For each frequency, which was determined the turntable azimuth and elevation angle will be adjusted. The turntable azimuth will slowly vary by  $\pm 22.5^{\circ}$  around this value. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the elevation angle will also slowly vary by  $\pm 45^{\circ}$ . During this action, the value of emission is also continuously measured. The elevation angle of the highest emission will also be recorded and adjusted.

- Turntable angle range:  $\pm 22.5^{\circ}$  around the determined value
- Elevation angle range:  $\pm 45^{\circ}$  around the determined value
- Antenna Polarisation: max. value determined in step 1

### Step 3: Final measurement with RMS detector

With the settings determined in step 2, the final measurement will be performed:

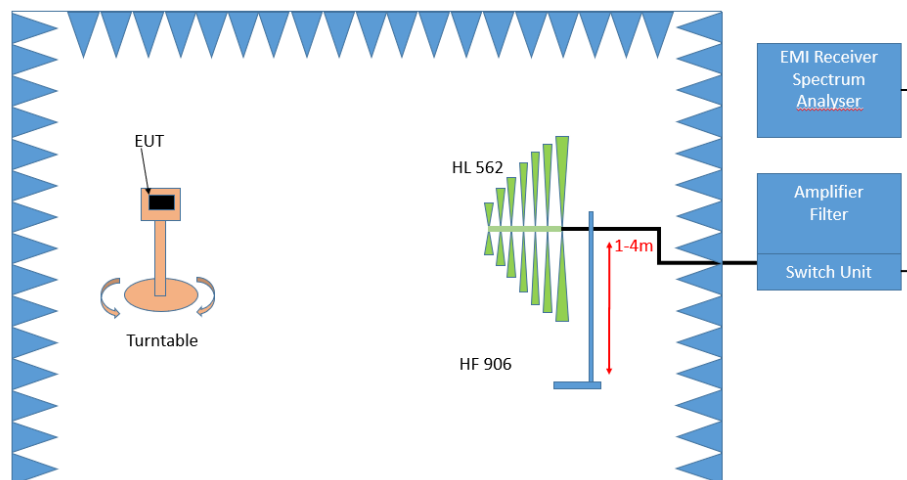
### 4. Measurement 18 GHz – 26 GHz

The only difference to measurement procedure in the frequency range 960 MHz – 18 GHz, is the reduced measurement distance of 0.5 m. The measurement procedure is identical.

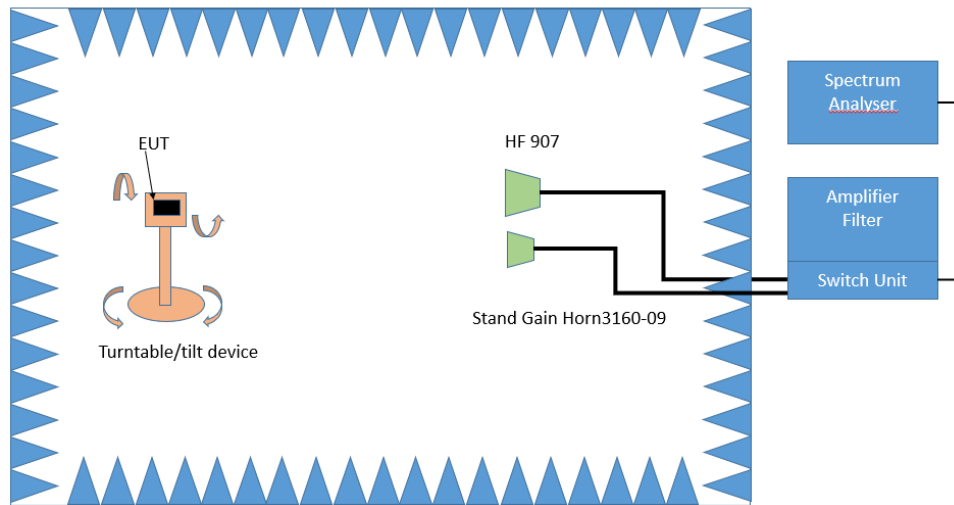
### 5. Measurement 26 GHz – 40 GHz

The measurement settings and procedure for this frequency range are identical to the frequency range 960 MHz to 18 GHz.

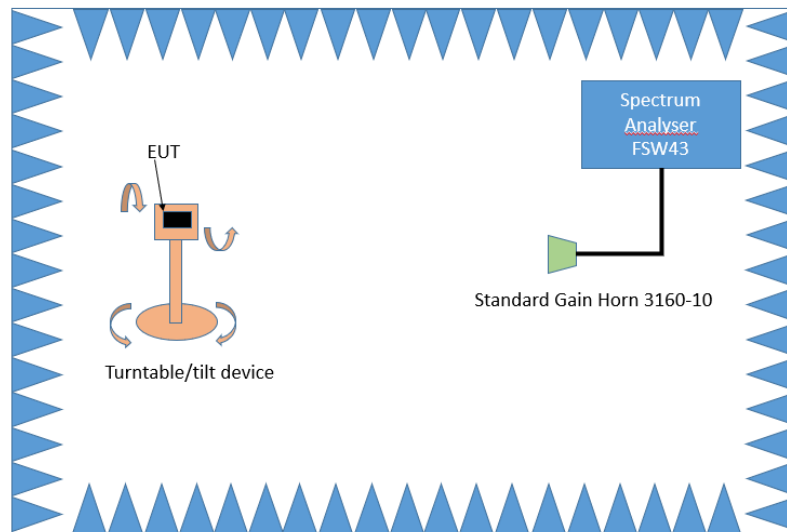
The Test was performed radiated in a Semi and Fully Anechoic Chamber in the following setups:



Test Setup; Spurious Emission Radiated (SAC), 30 MHz- 1GHz



Test Setup; Spurious Emission Radiated (FAC), 1 GHz-26.5 GHz



Test Setup; Spurious Emission Radiated (FAC), 26.5 – 40 GHz

Conducted test setup:



Test Setup FCC; Conducted spurious emissions

## 4.5.2 TEST REQUIREMENTS / LIMITS

### FCC Part 15, Subpart F, §15.519 (c)

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

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

### FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

| Frequency in MHz | Limit (µV/m)     | Measurement distance (m) | Limits (dBµV/m)    |
|------------------|------------------|--------------------------|--------------------|
| 0.009 – 0.49     | 2400/F(kHz)@300m | 3                        | (48.5 – 13.8)@300m |
| 0.49 – 1.705     | 24000/F(kHz)@30m | 3                        | (33.8 – 23.0)@30m  |
| 1.705 – 30       | 30@30m           | 3                        | 29.5@30m           |

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according FCC 15.31 (2).

| Frequency in MHz | Limit (µV/m) | Measurement distance (m) | Limits (dBµV/m) |
|------------------|--------------|--------------------------|-----------------|
| 30 – 88          | 100@3m       | 3                        | 40.0@3m         |
| 88 – 216         | 150@3m       | 3                        | 43.5@3m         |
| 216 – 960        | 200@3m       | 3                        | 46.0@3m         |

### RSS-220, 5.3.1 (c)

Radiated emissions at or below 960 MHz from a device shall not exceed the limits in section 3.4.

### RSS-220, 3.4

Radiated emissions at or below 960 MHz for all subclasses of UWB device shall not exceed the following limits. Measurements of radiated emissions at and below 960 MHz are to be made using a CISPR quasi-peak detector. CISPR measurement bandwidth specifications are to be used.

| Frequency in MHz | Limit (µV/m)     | Measurement distance (m) | Limits (dBµV/m)    |
|------------------|------------------|--------------------------|--------------------|
| 0.009 – 0.49     | 2400/F(kHz)@300m | 3                        | (48.5 – 13.8)@300m |
| 0.49 – 1.705     | 24000/F(kHz)@30m | 3                        | (33.8 – 23.0)@30m  |
| 1.705 – 30       | 30@30m           | 3                        | 29.5@30m           |

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according FCC 15.31 (2).

| Frequency in MHz | Limit (μV/m) | Measurement distance (m) | Limits (dBμV/m) |
|------------------|--------------|--------------------------|-----------------|
| 30 – 88          | 100@3m       | 3                        | 40.0@3m         |
| 88 – 216         | 150@3m       | 3                        | 43.5@3m         |
| 216 – 960        | 200@3m       | 3                        | 46.0@3m         |

#### RSS-220, 5.3.1 (d)

Radiated emissions above 960 MHz from a device shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz.

| Frequency in MHz | EIRP in dBm |
|------------------|-------------|
| 960 – 1610       | -75.3       |
| 1610 – 4.750     | -70.0       |
| 4750 – 10600     | -41.3       |
| Above 10600      | -61.3       |

#### 4.5.3 TEST PROTOCOL

**Ambient**  
**temperature:** 23-24 °C  
**Air Pressure:** 1000–1016 hPa  
**Humidity:** 38–41 %

| Operating Band: 3100 - 10600 MHz [FCC 15.519] |                      |                      |          |           |             |                      |
|-----------------------------------------------|----------------------|----------------------|----------|-----------|-------------|----------------------|
| Operating Frequency                           | Spurious Freq. [MHz] | Spurious Level [dBm] | Detector | RBW [kHz] | Limit [dBm] | Margin to Limit [dB] |
| low                                           | 3024.2               | -59.7                | RMS      | 1000      | -61.3       | -1.6                 |
| mid                                           | 3024.2               | -60.5                | RMS      | 1000      | -61.3       | -0.8                 |
| high                                          | 3024.2               | -60.6                | RMS      | 1000      | -61.3       | -0.7                 |

| Operating Band: 3100 - 10600 MHz [ISED RSS-220] |                      |                      |          |           |             |                      |
|-------------------------------------------------|----------------------|----------------------|----------|-----------|-------------|----------------------|
| Operating Frequency                             | Spurious Freq. [MHz] | Spurious Level [dBm] | Detector | RBW [kHz] | Limit [dBm] | Margin to Limit [dB] |
| low                                             | 3024.2               | -59.7                | RMS      | 1000      | -70.0       | -10.3                |
| mid                                             | 3024.2               | -60.5                | RMS      | 1000      | -70.0       | -9.5                 |
| high                                            | 3024.2               | -60.6                | RMS      | 1000      | -70.0       | -9.4                 |

| Operating Band: 3100 - 10600 MHz [FCC 15.209] |                      |                      |          |           |               |                      |
|-----------------------------------------------|----------------------|----------------------|----------|-----------|---------------|----------------------|
| Operating Frequency                           | Spurious Freq. [MHz] | Spurious Level [dBm] | Detector | RBW [kHz] | Limit [dBm]*) | Margin to Limit [dB] |
| low                                           | 3024.2               | -59.7                | RMS      | 1000      | -31.7         | 28.0                 |
| mid                                           | 3024.2               | -60.5                | RMS      | 1000      | -31.7         | 28.8                 |
| high                                          | 3024.2               | -60.6                | RMS      | 1000      | -31.7         | 28.9                 |

| Operating Band: 3100 - 10600 MHz [ISED RSS-Gen] |                      |                      |          |           |               |                      |
|-------------------------------------------------|----------------------|----------------------|----------|-----------|---------------|----------------------|
| Operating Frequency                             | Spurious Freq. [MHz] | Spurious Level [dBm] | Detector | RBW [kHz] | Limit [dBm]*) | Margin to Limit [dB] |
| low                                             | 3024.2               | -59.7                | RMS      | 1000      | -31.7         | 28.0                 |
| mid                                             | 3024.2               | -60.5                | RMS      | 1000      | -31.7         | 28.8                 |
| high                                            | 3024.2               | -60.6                | RMS      | 1000      | -31.7         | 28.9                 |

\*) Limit calculation FCC 15.209 7 RSS-Gen:

- Above 906 MHz  $\rightarrow$  500  $\mu$ V/m@3m  $\rightarrow$  54 dB $\mu$ V/m@3m
- P(EIRP)[dBm] = E[dB $\mu$ V/m@3m] – 95.2  $\rightarrow$  Limit: P(EIRP) = -41.2 dBm
- Correction due to different measurement distance: 3m  $\rightarrow$  1m: +9.5 dB  $\rightarrow$  Limit: -31.7 dBm

According customers declaration:

The emission at 3024.2 MHz comes from the digital circuitry/IC of the EUT not intended or direct part of UWB transmission through UWB antenna. The signal is radiated by the enclosure of the EUT. The built-in UWB antenna, is from their physical dimensions, too small to emit radio waves in this frequency range. The main UWB signal power and emission at 3024.2 MHz occur at the different angles of the EUT that also indicates that the emissions are not from the UWB antenna.

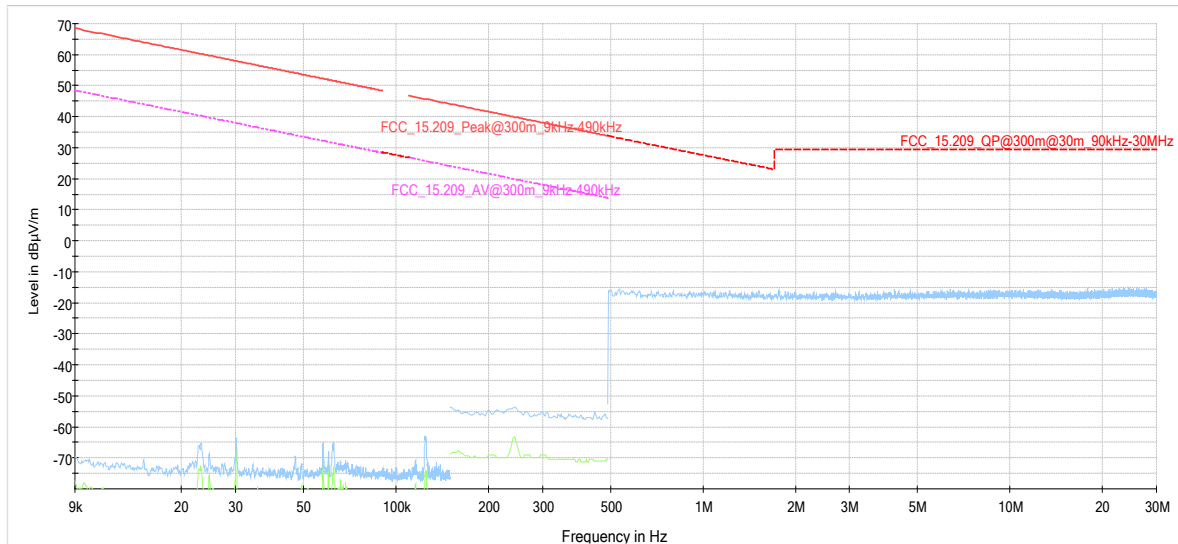
To demonstrate this, relative measurements of the disturbance at 3024.2 MHz, with different operating modes, have been performed. This shows that the disturbance is complete independent from the UWB transmission technology. For details please see the measurements plots in the next-sub-clause.

Also measurements with a sample with a temporary antenna connector have been performed. One time conducted on the temporary antenna port, a second time radiated with the antenna port terminated with 50 Ohm (Setup: S01\_AA13). For details please see the measurements plots on page 45.

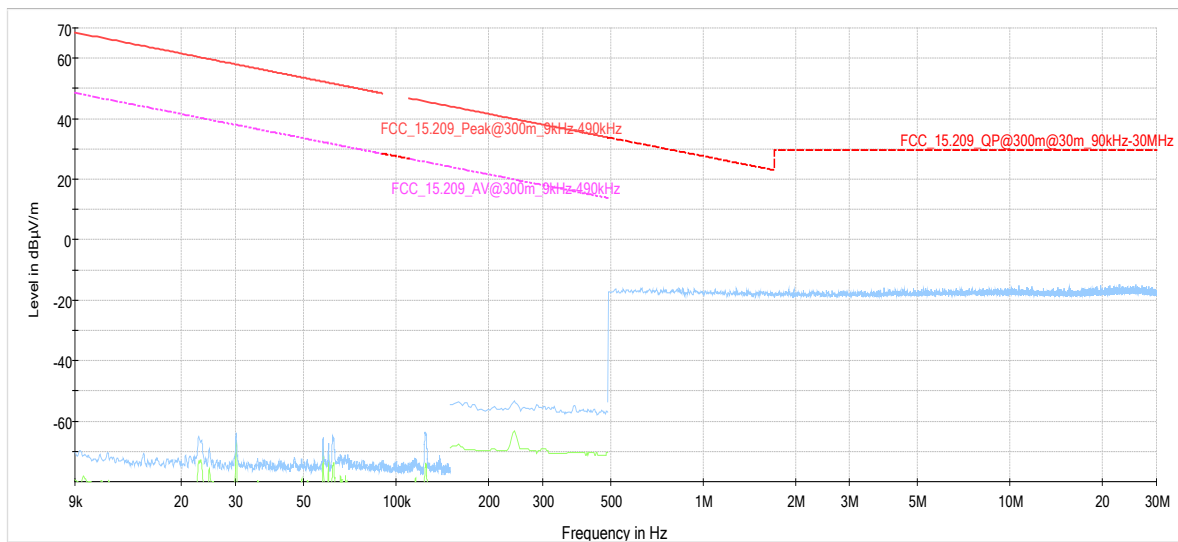
Remark: Please see next sub-clause for the measurement plot.

#### 4.5.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

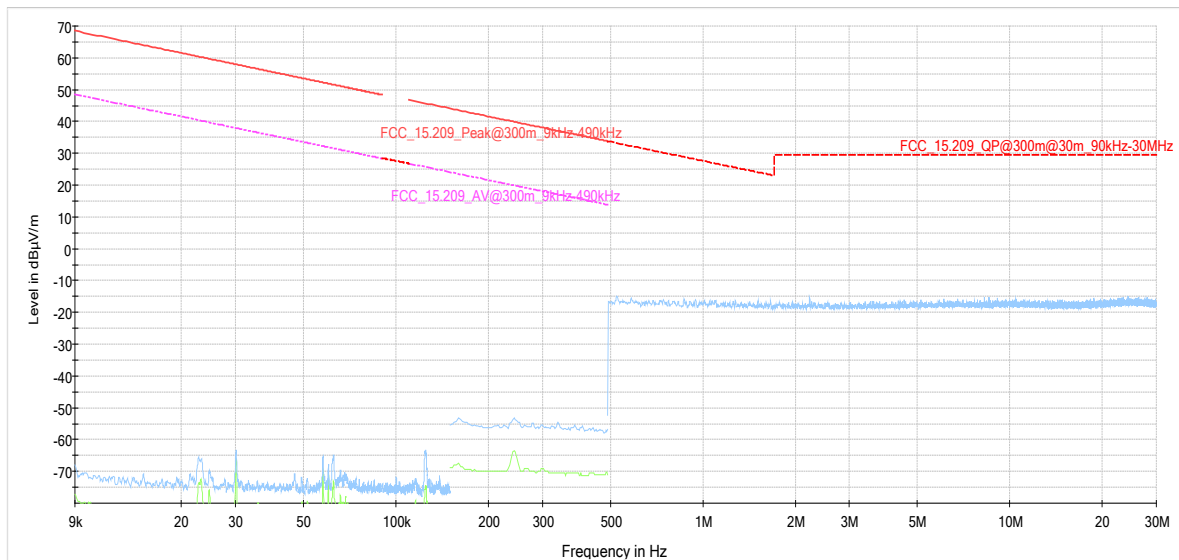
Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 9 kHz – 30 MHz, Channel = high  
(S01\_AA10)



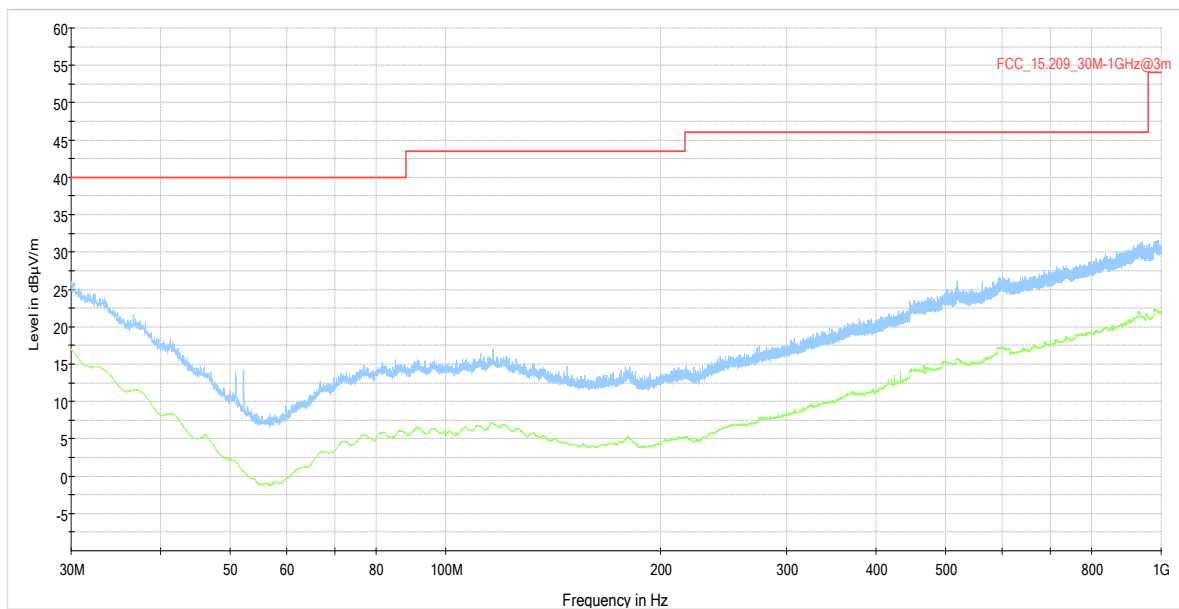
Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 9 kHz – 30 MHz, Channel = mid  
(S01\_AA10)



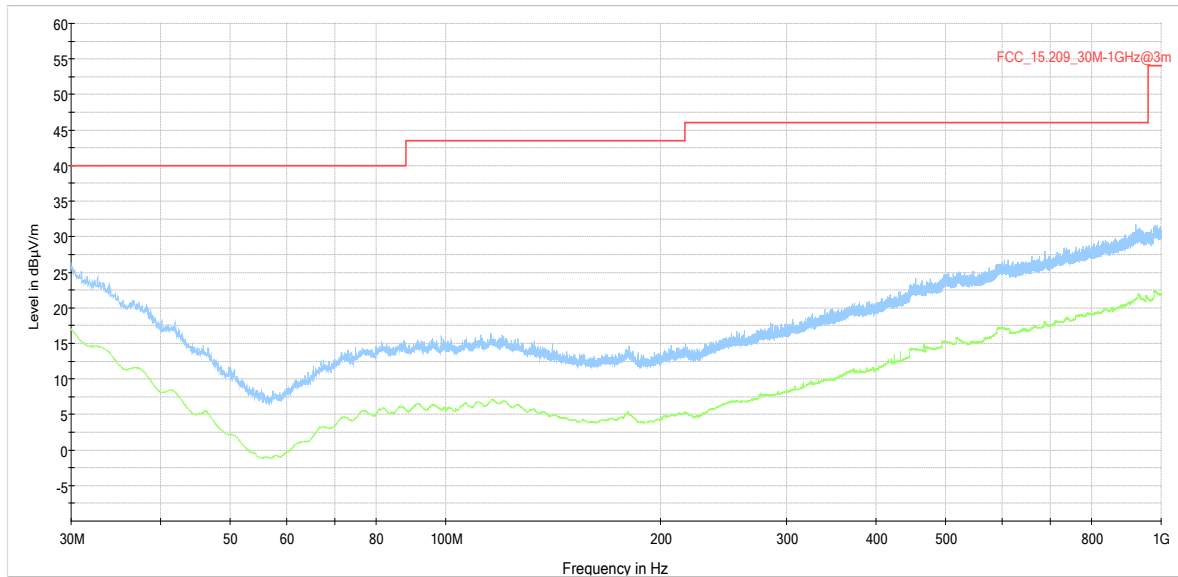
Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 9 kHz – 30 MHz, Channel = high  
(S01\_AA10)



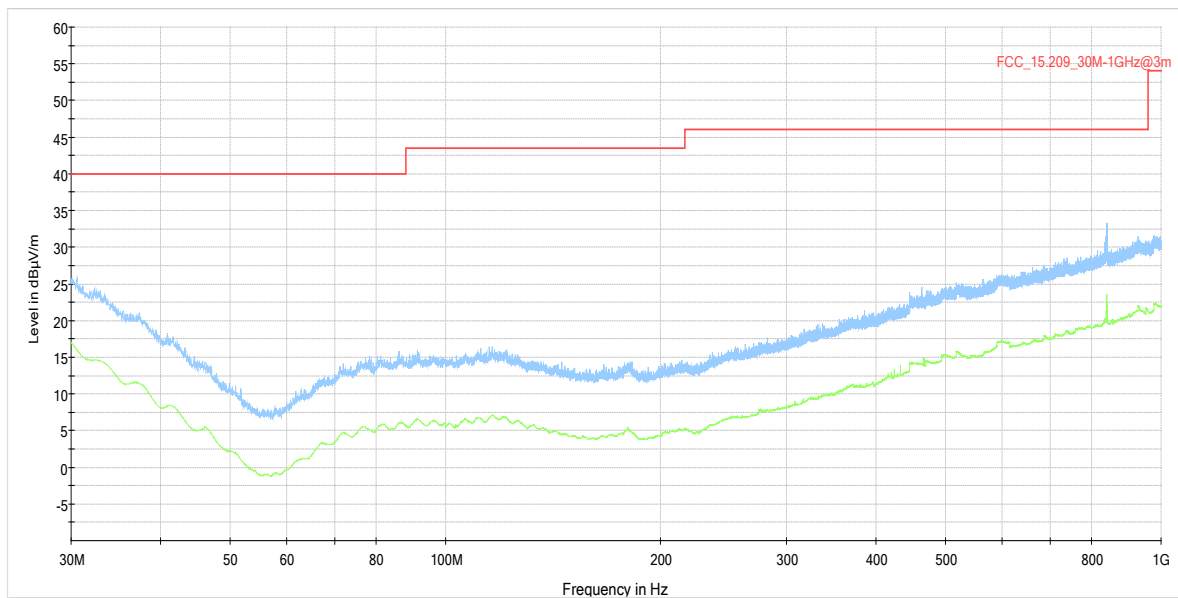
Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 30 MHz – 960 MHz, Channel = low  
(S01\_AA10)



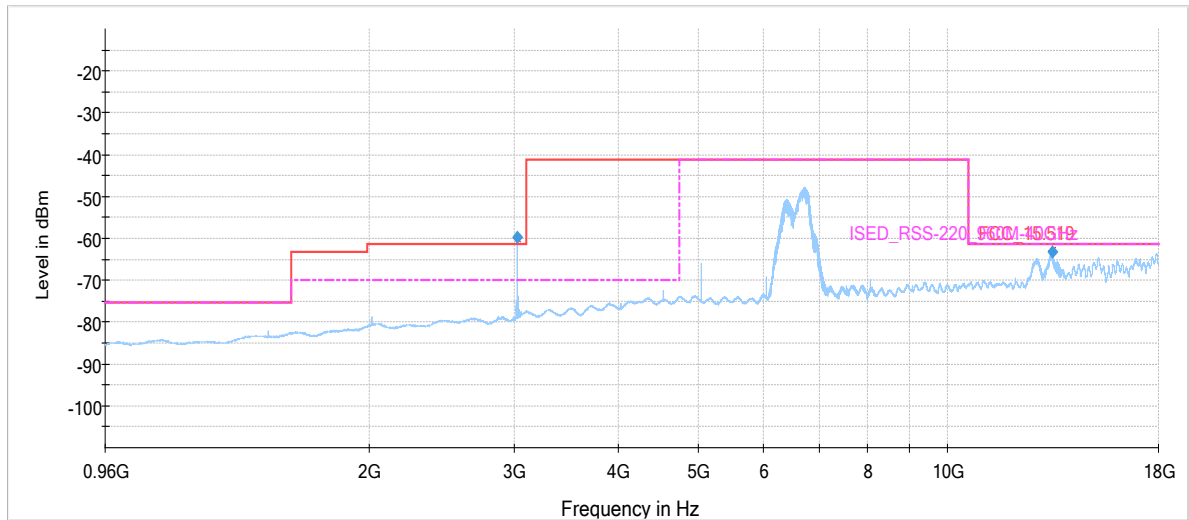
Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 30 MHz – 960 MHz, Channel = mid  
(S01\_AA10)



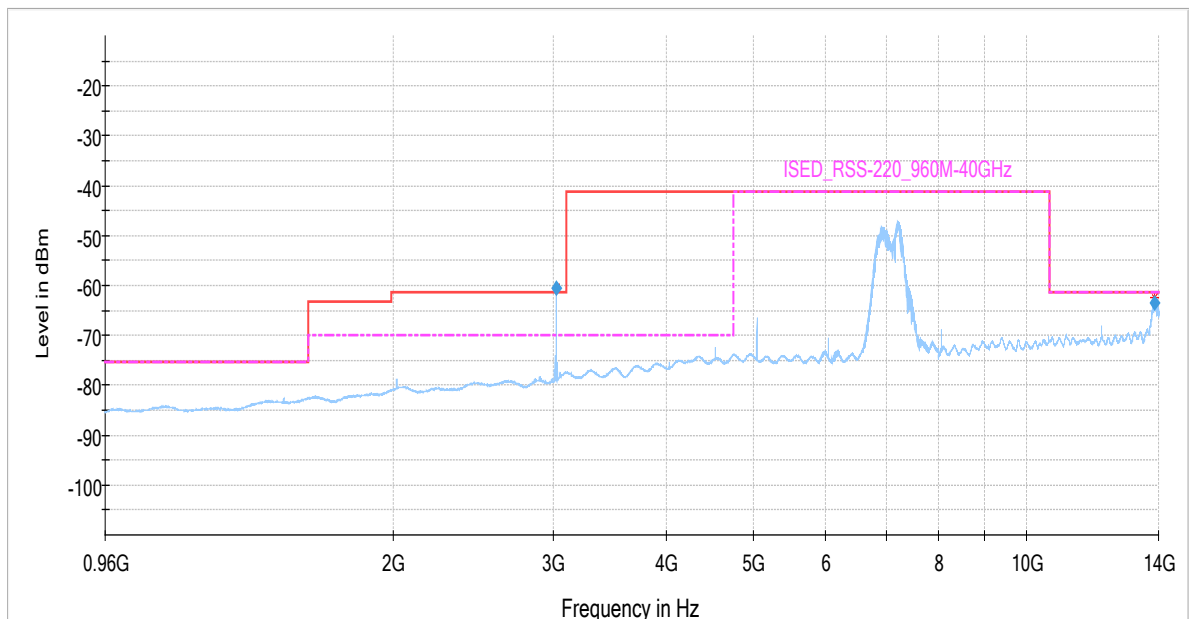
Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 30 MHz – 960 MHz, Channel = high  
(S01\_AA10)



Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 960 MHz – 18 GHz, Channel = low  
(S01\_AA10)

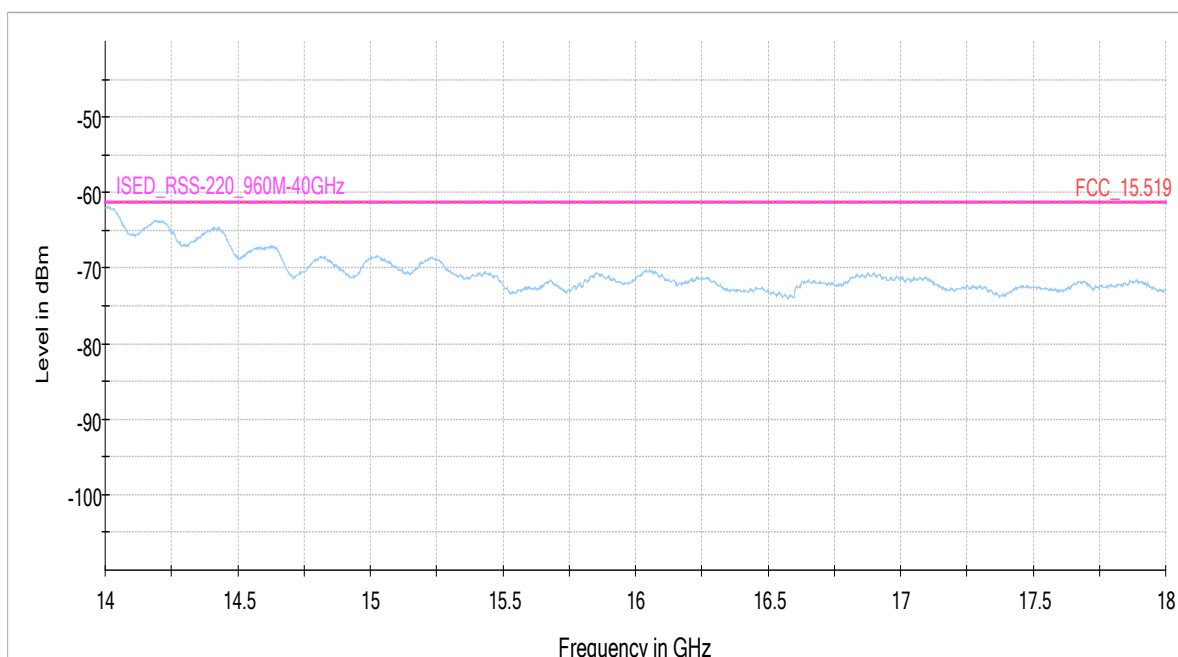


Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 960 MHz – 18 GHz, Channel = mid  
(S01\_AA10)



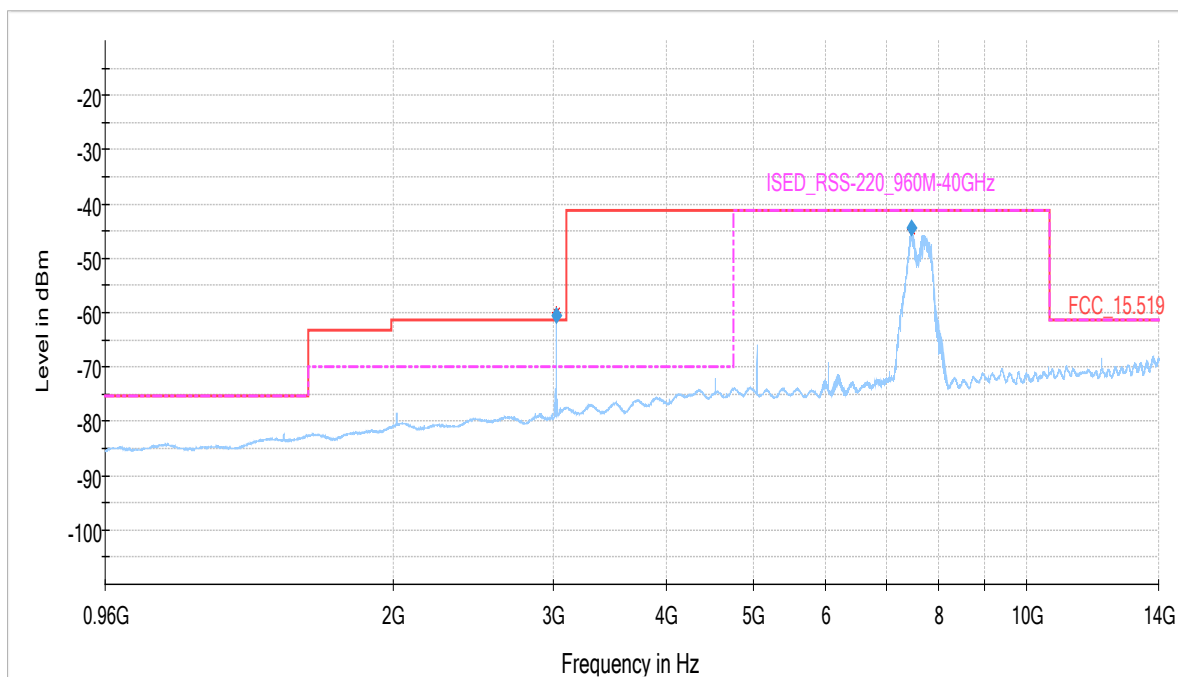
960 MHz – 14 GHz

Note: Frequency range splitted, Peak at 13.8 GHz harmonic disturbtion produced by the test system.



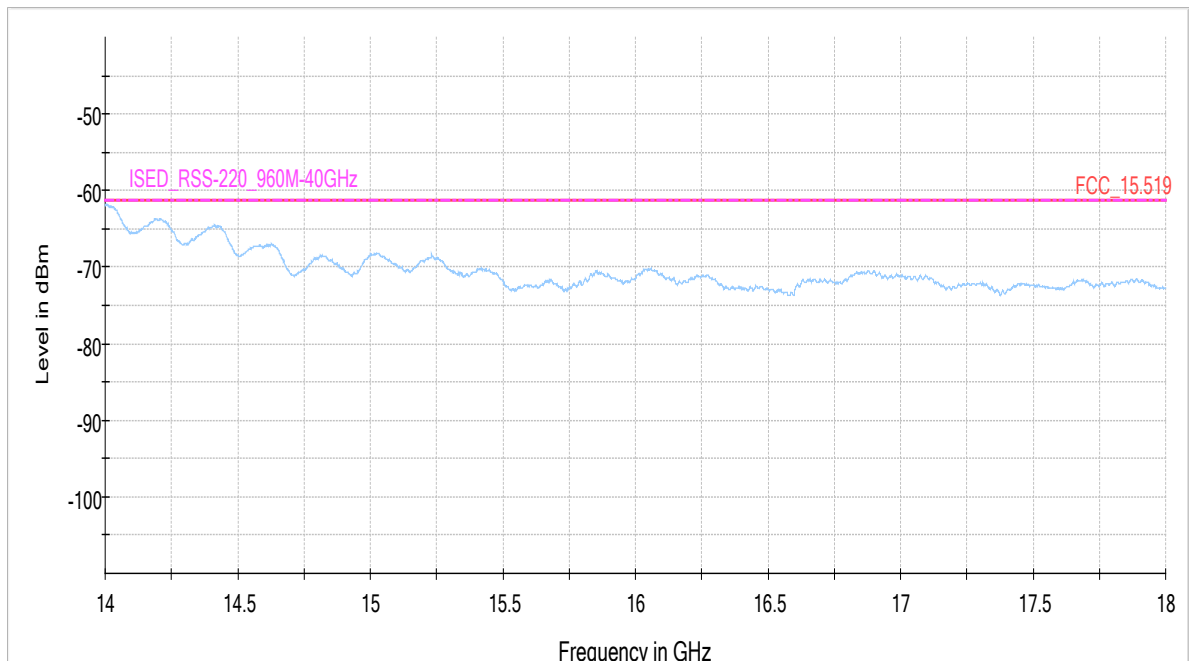
14 GHz – 18 GHz

Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 960 MHz – 18 GHz, Channel = high  
(S01\_AA10)



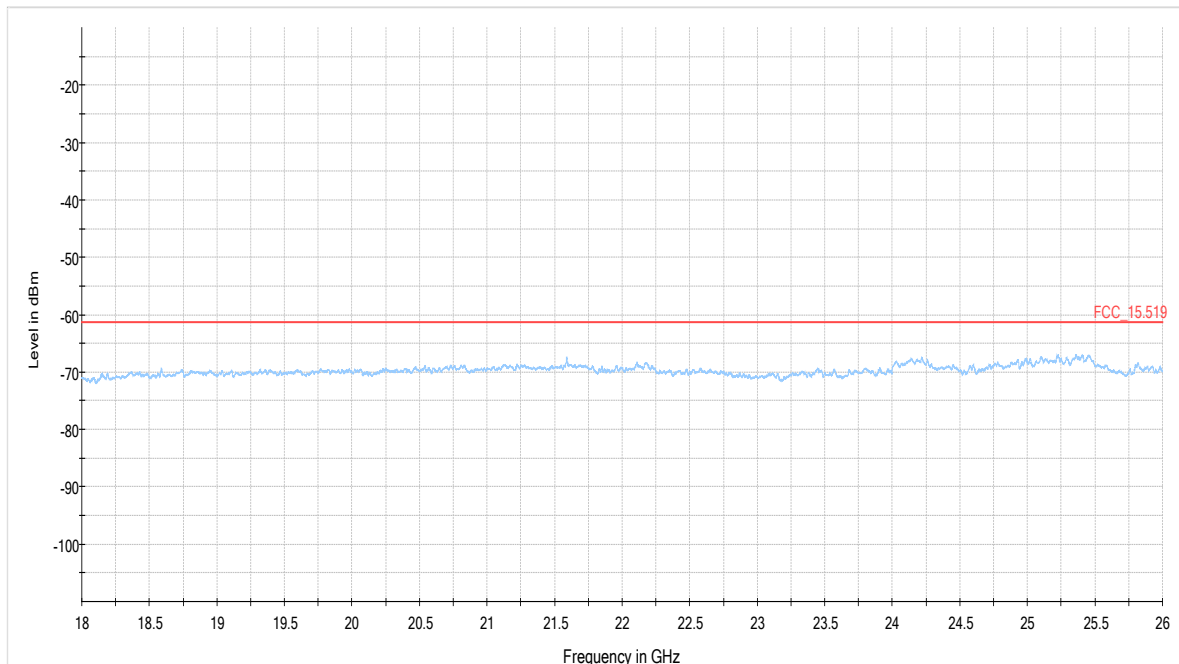
960 MHz – 14 GHz

Note: Frequency range splitted

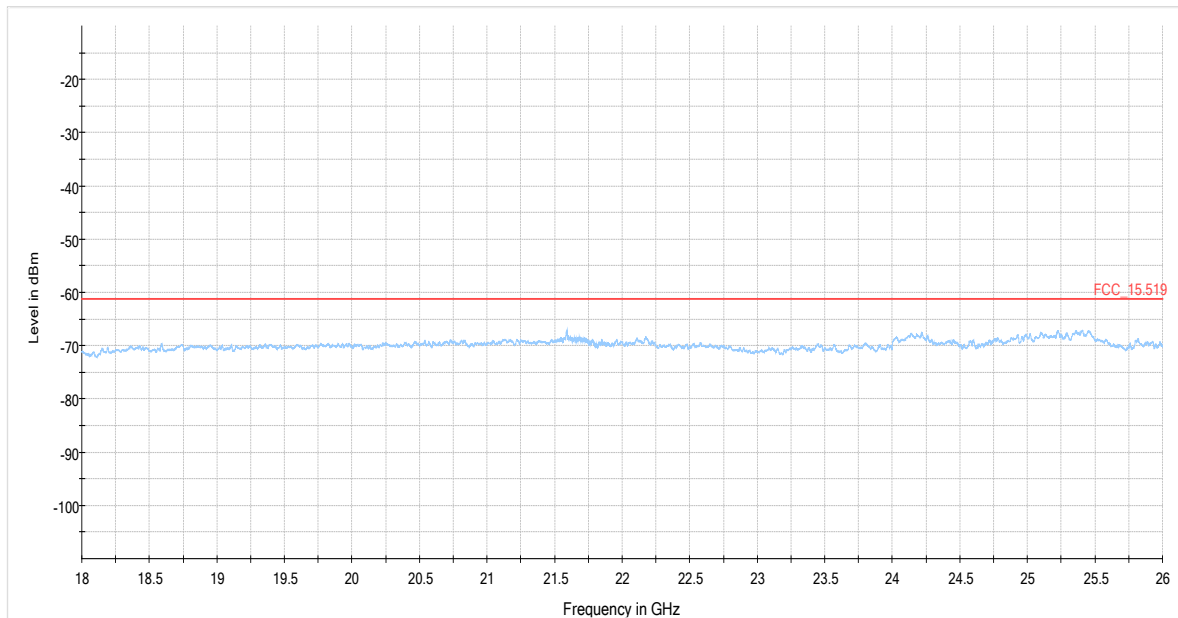


14 GHz – 18 GHz

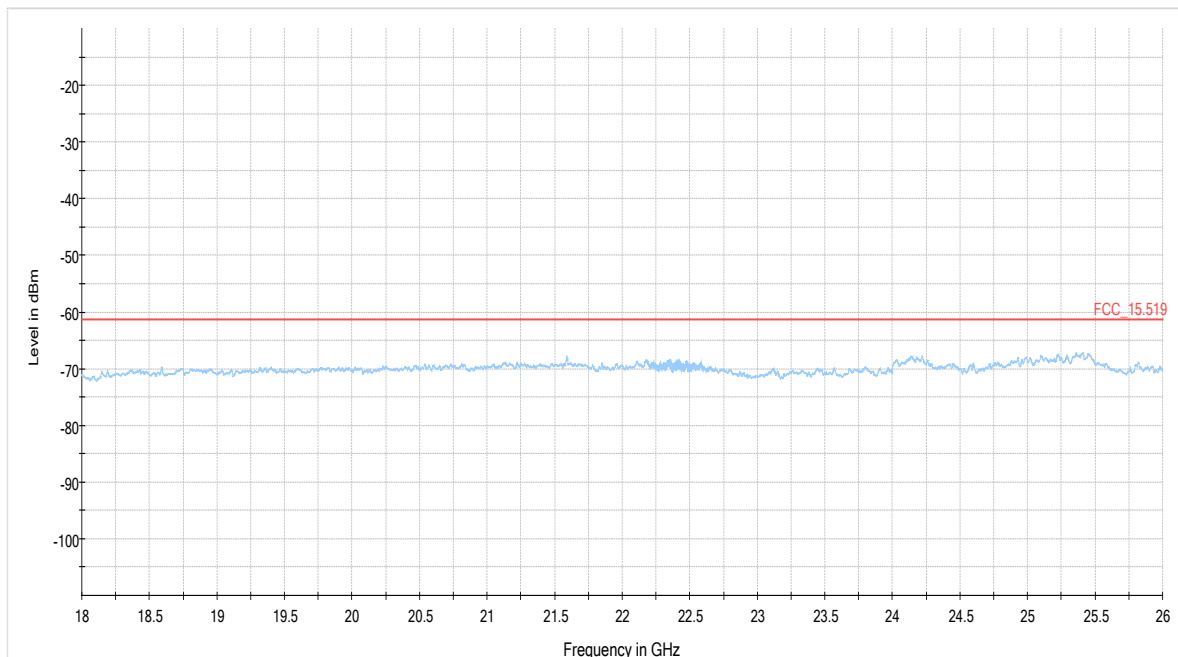
Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 18 GHz – 26 GHz, Channel = low  
(S01\_AA10)



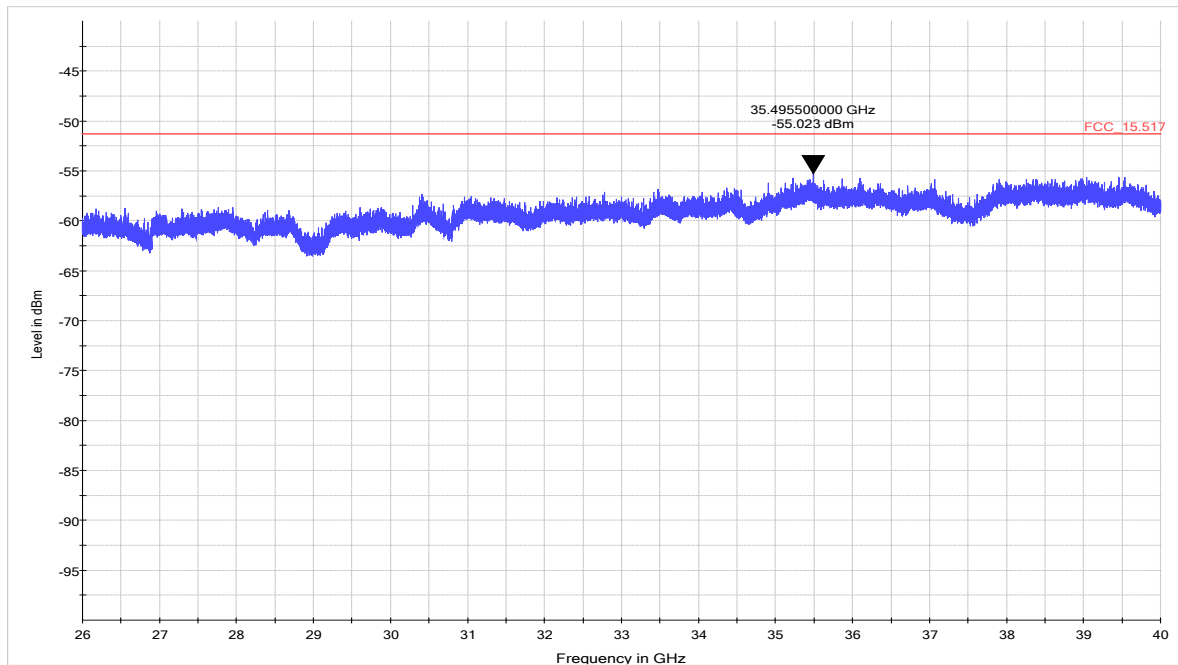
Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 18 GHz – 26 GHz, Channel = mid  
(S01\_AA10)



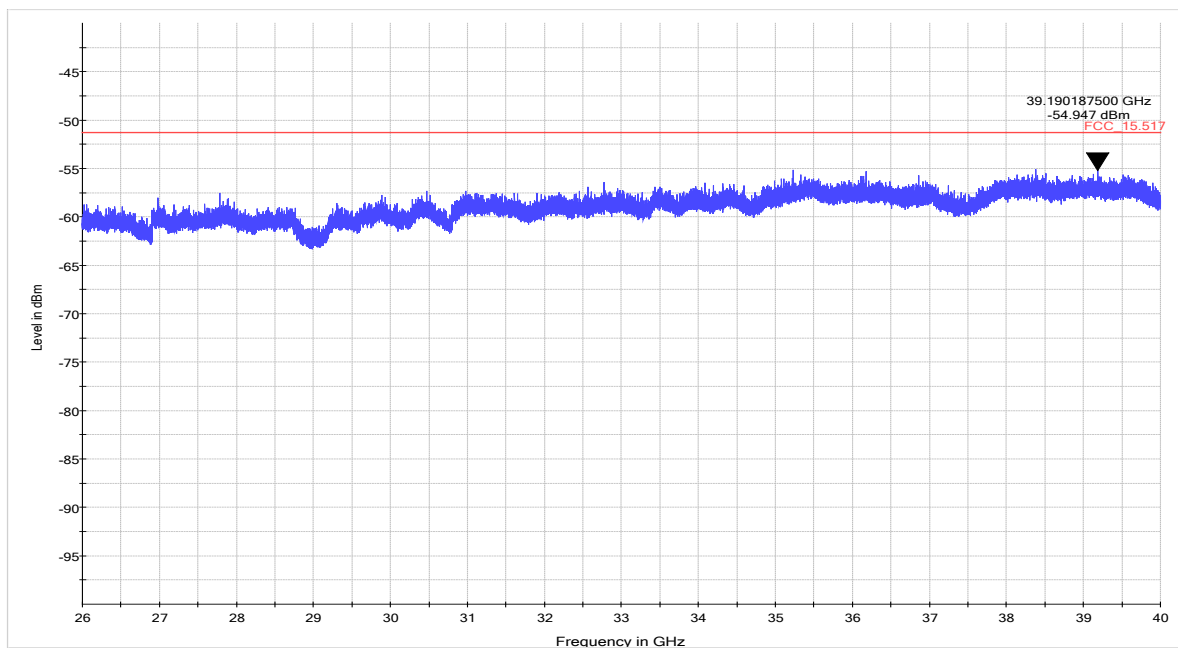
Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 18 GHz – 26 GHz, Channel = high  
(S01\_AA10)



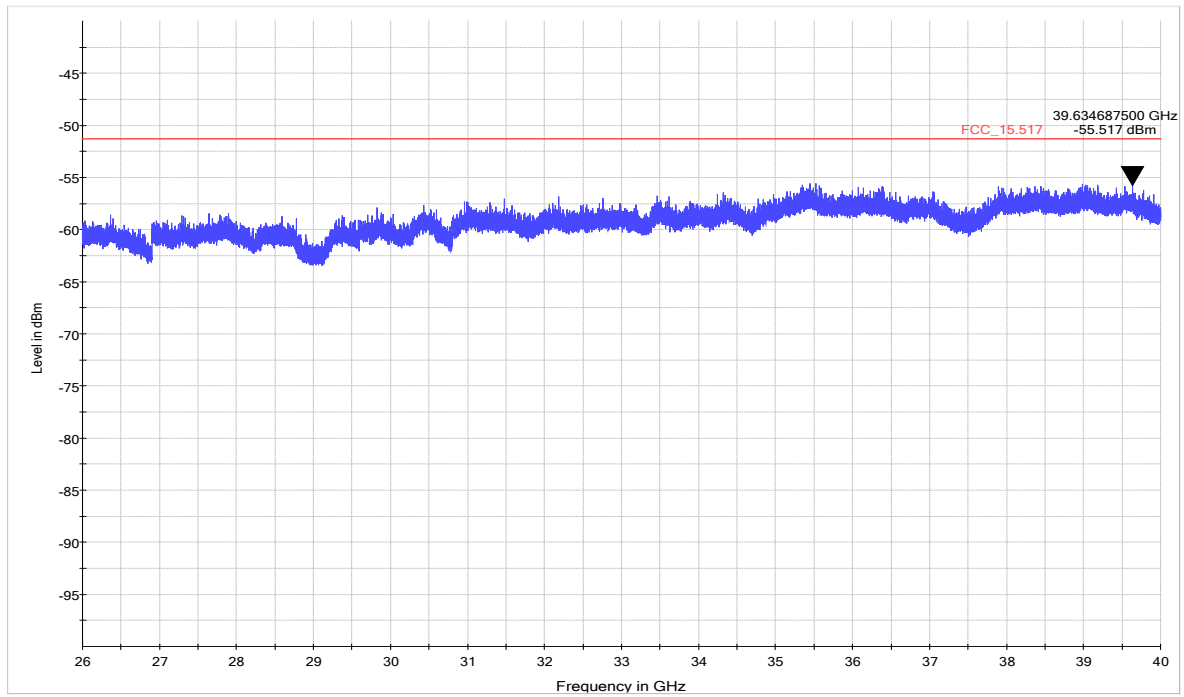
Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 26 GHz – 40 GHz, Channel = low  
(S01\_AA10)



Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 26 GHz – 40 GHz, Channel = mid  
(S01\_AA10)

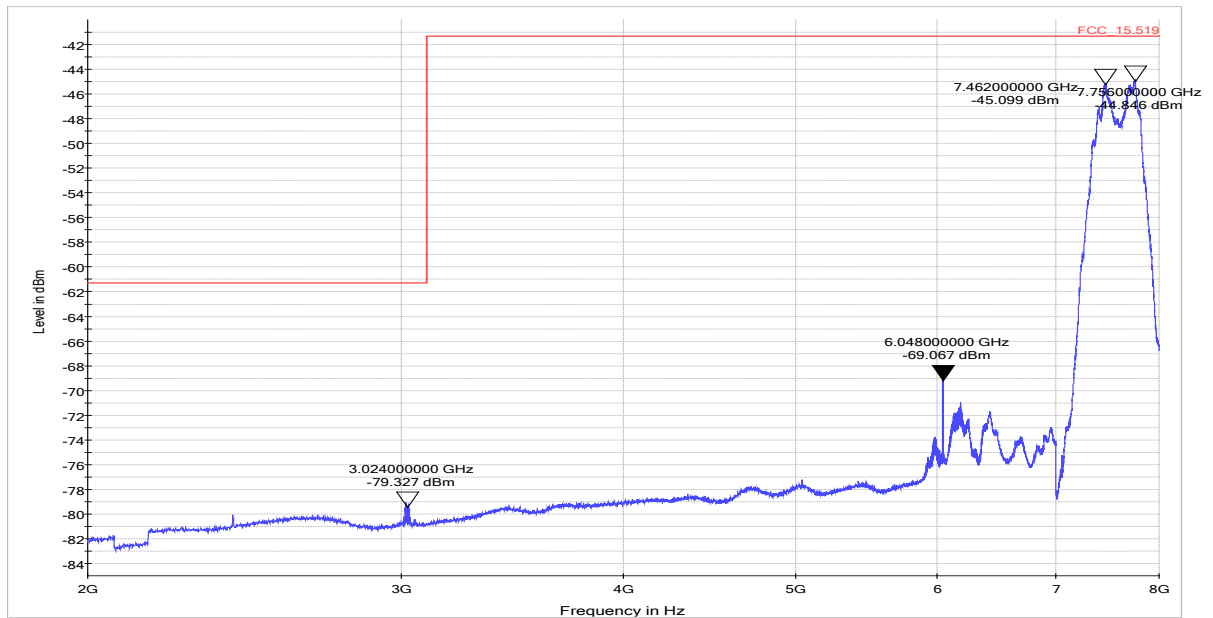


Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 26 GHz – 40 GHz, Channel = high  
(S01\_AA10)



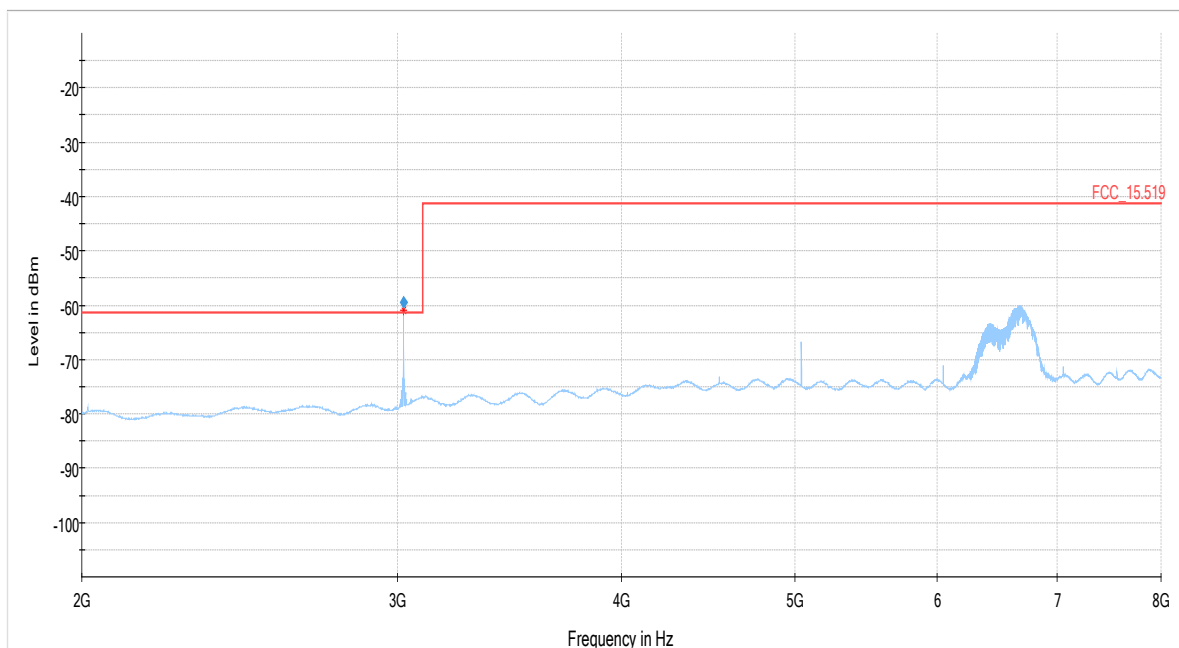
Setup: S01\_AA13

Additional measurements for the disturbance @3024.2 MHz, to show that the disturbance will not be radiated via the antenna



TX, 7560 MHz, conducted measurement at antenna connector

For this part of the test, the conducted measurement setup, described on pages 32, was used



TX, 7560 MHz, radiated measurement with antenna connector terminated with 50 Ohm.  
For this part of the test, the default radiated measurement setup, described on pages 29 – 32, was used.

#### 4.5.5 TEST EQUIPMENT USED

- Radiated Emissions

## 4.6 RADIATED EMISSIONS IN GNSS BANDS

Standard      **FCC Part 15 Subpart F**  
                  **FCC Part 15 Subpart C**

**The test was performed according to:**  
ANSI C63.10

### 4.6.1 TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.

All steps were performed with one height (1.5 m) of the receiving antenna only.

The measurement procedure is implemented into the EMI test software EMC32 from R&S.

Exploratory tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is also performed at 3 axes.

A pre-check is performed while the EUT is powered from a DC power source.

After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

#### **1. Measurement 1164 MHz – 1240 MHz, 1559 MHz – 1610 MHz**

The following spectrum analyser setting are used for all steps:

- Measurement distance: 1 m
- Detector: RMS
- RBW: 1 kHz
- VBW: 3 kHz
- Measuring time: 1 ms / Sweep point
- Sweep Points: 1 / MHz [Span]

##### **Step 1: Preliminary scan**

Settings for step 1:

- Turntable angle range:  $-180^{\circ}$  to  $90^{\circ}$
- Turntable step size:  $45^{\circ}$
- Elevation step size:  $90^{\circ}$
- Polarisation: Horizontal + Vertical

##### **Step 2: Adjustment measurement**

In this step the accuracy of the turntable azimuth elevation will be improved. This is necessary to find out the maximum value of every frequency.

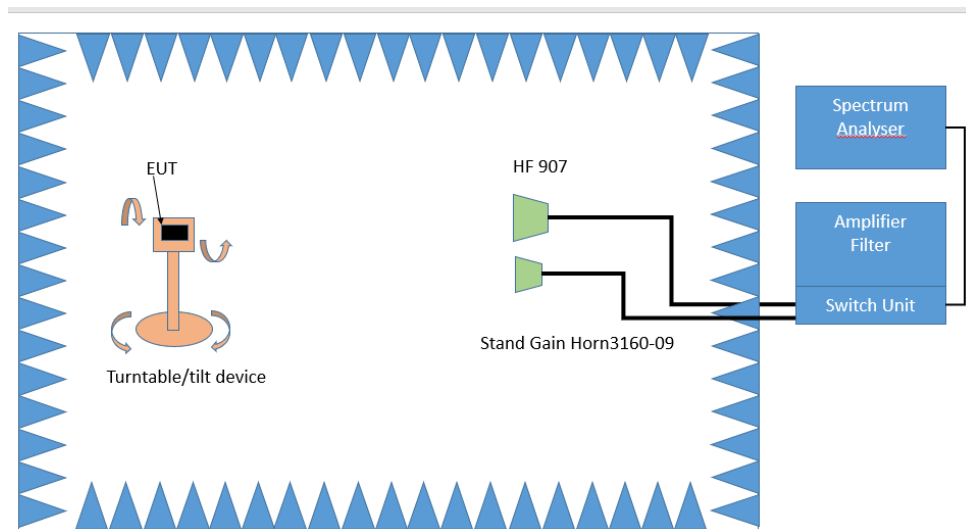
For each frequency, which was determined the turntable azimuth and elevation angle will be adjusted. The turntable azimuth will slowly vary by  $\pm 22.5^{\circ}$  around this value. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the elevation angle will also slowly vary by  $\pm 45^{\circ}$ . During this action, the value of emission is also continuously measured. The elevation angle of the highest emission will also be recorded and adjusted.

- Turntable angle range:  $\pm 22.5^{\circ}$  around the determined value
- Elevation angle range:  $\pm 45^{\circ}$  around the determined value
- Antenna Polarisation: max. value determined in step 1

### Step 3: Final measurement with RMS detector

With the settings determined in step 2, the final measurement will be performed.

The Test was performed radiated in a Fully Anechoic Chamber in the following setup:



Test Setup; Spurious Emission Radiated (FAC), 1 GHz-26.5 GHz

## 4.6.2 TEST REQUIREMENTS / LIMITS

### FCC Part 15, Subpart F, §15.519 (d)

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

| Frequency in MHz | EIRP in dBm |
|------------------|-------------|
| 1164 – 1240      | -85.3       |
| 1559 - 1610      | -85.3       |

### RSS-220, 5.3.1 (e)

In addition to the limits specified in paragraph (d) of this section, radiated emissions shall not exceed the following average limits when measured using a resolution bandwidth greater than or equal to 1 kHz. The measurements shall demonstrate compliance with the stated limits at whatever resolution bandwidth is used.

| Frequency in MHz | EIRP in dBm |
|------------------|-------------|
| 1164 – 1240      | -85.3       |
| 1559 - 1610      | -85.3       |

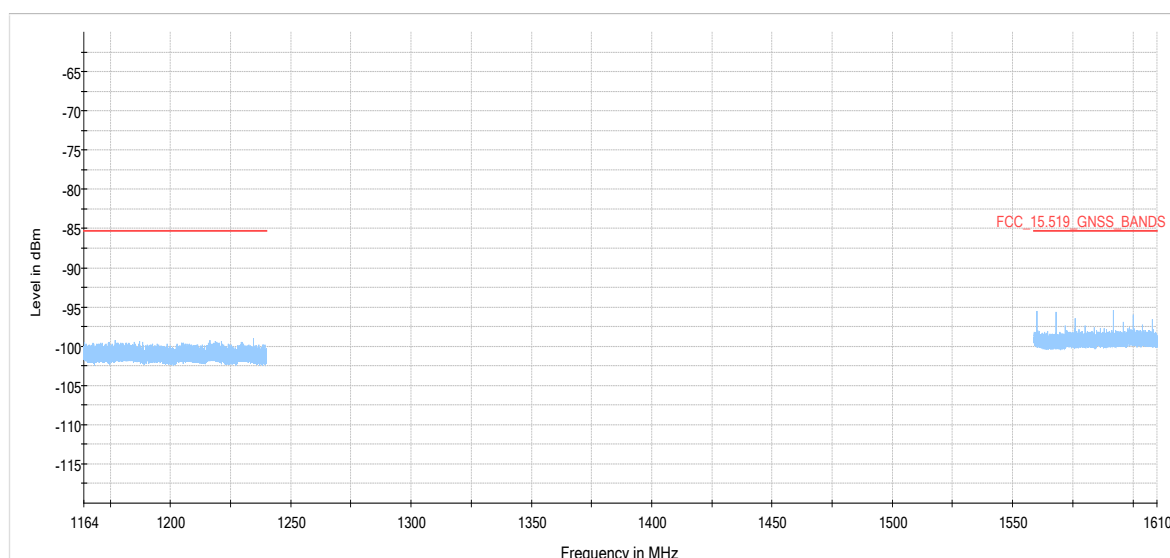
#### 4.6.3 TEST PROTOCOL

**Ambient**  
**temperature:** 25 °C  
**Air Pressure:** 1023 hPa  
**Humidity:** 28 %

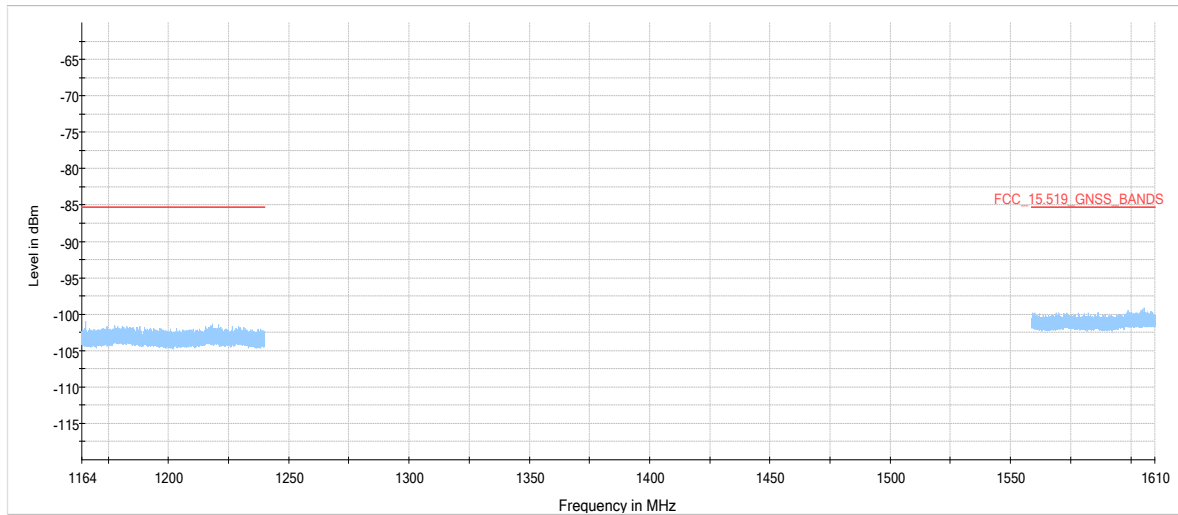
| Operating Band: 3100 - 10600 MHz |                      |                      |          |           |             |                      |
|----------------------------------|----------------------|----------------------|----------|-----------|-------------|----------------------|
| Operating Frequency              | Spurious Freq. [MHz] | Spurious Level [dBm] | Detector | RBW [kHz] | Limit [dBm] | Margin to Limit [dB] |
| low                              | - - -                | - - -                | - - -    | 1         | -85.3       | - - -                |
| mid                              | - - -                | - - -                | - - -    | 1         | -85.3       | - - -                |
| high                             | - - -                | - - -                | - - -    | 1         | -85.3       | - - -                |

#### 4.6.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

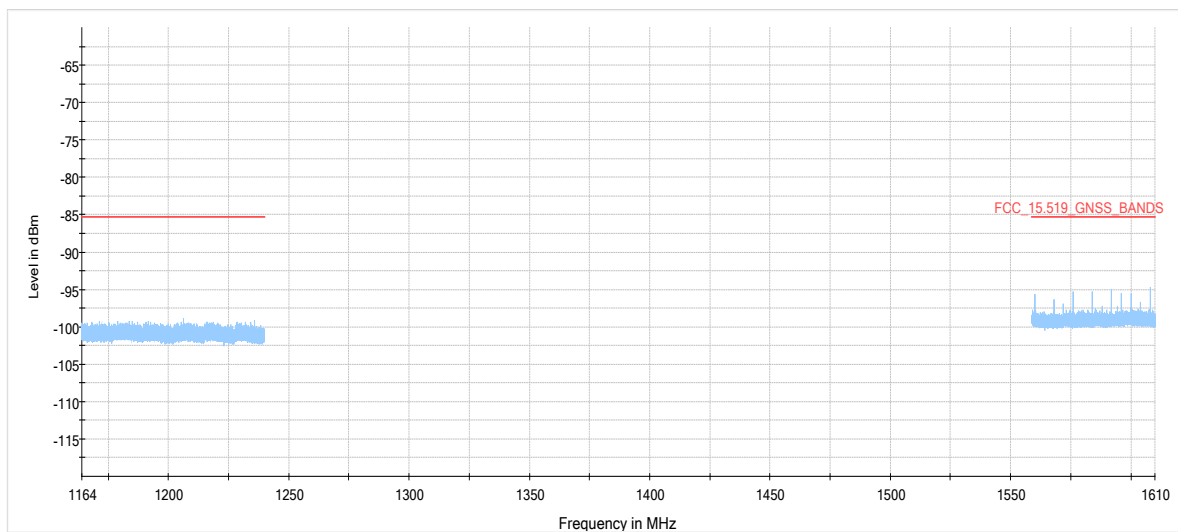
Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 1164 MHz -1240 MHz & 1559 MHz – 1610 MHz, Channel = low  
(S01\_AA10)



Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 1164 MHz -1240 MHz & 1559 MHz – 1610 MHz, Channel = mid  
(S01\_AA10)



Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Frequency range 1164 MHz -1240 MHz & 1559 MHz – 1610 MHz, Channel = high  
(S01\_AA10)



#### 4.6.5 TEST EQUIPMENT USED

- Radiated Emissions

## 4.7 ASSOCIATED RECEIVER / TRANSMISSION TIMES

Standard **FCC Part 15 Subpart F**

**The test was performed according to:**  
ANSI C63.10

### 4.7.1 TEST DESCRIPTION

**Definition:**

The Equipment Under Test (EUT) was set up to perform the transmission times measurements.

**Test Procedure: Transmission time:**

The Equipment Under Test (EUT) was set up on a non-conductive support in a shielded room. The measurement antenna was, via a short coax-cable, directly connected to a spectrum analyser. The distance between measurement antenna and the EUT was approximately 0.5 m. Because in this test only the timing behaviour of the EUT is checked, the test setup was not calibrated to absolute power levels. No associated receiver for the EUT was in range. For this reason, no acknowledgement signal could be transmitted to the EUT.

**Test Procedure: Associated Receiver:**

The Equipment Under Test (EUT) was set up on a non-conductive support in a shielded room. The measurement antennas (horn antenna for UWB (7040 MHz) and UHF (434 MHz) and a loop antenna for the LF signal (125 kHz) were, via a short coax-cable and a 3 dB coupler, directly connected to a spectrum analyser. Because in this test only the timing behaviour of the EUT is checked, the test setup was not calibrated to absolute power levels. The spectrum analyser was setup to observe all three RF transmissions simultaneously. The test was performed twice. The first test run was performed with an associated receiver in range, the second one is no associated receiver in range. For detail please see chapter "Test Protocol".

### 4.7.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart F, §15.519 (a) (1)

A UWB device operating under the provisions of this section shall transmit only when it is sending information to an associated receiver. The UWB intentional radiator shall cease transmission within 10 seconds unless it receives an acknowledgement from the associated receiver that its transmission is being received. An acknowledgment of reception must continue to be received by the UWB intentional radiator at least every 10 seconds or the UWB device must cease transmitting.

RSS-220, 5.3.1 (b)

The device is to transmit only when it is sending information to an associated receiver. The device shall cease transmission of information within 10 seconds unless it receives an acknowledgement from the associated receiver that its transmission is being received. An acknowledgment of reception must continue to be received by the UWB device at least every 10 seconds or the UWB device shall cease transmitting any information other than periodic signals used for the establishment or re-establishment of a communication link with an associated receiver.

### 4.7.3 TEST PROTOCOL

#### Associated Receiver:

**Ambient temperature:** 26 °C  
**Air Pressure:** 1000 hPa  
**Humidity:** 31 %

| Operating Band: 3100 - 10600 MHz |                                 |                                  |                                   |        |
|----------------------------------|---------------------------------|----------------------------------|-----------------------------------|--------|
| Associated Receiver              | LF<br>(125 kHz)<br>Transmission | UHF<br>(434 MHz)<br>Transmission | UWB<br>(7040 MHz)<br>Transmission | Result |
| Yes                              | Yes                             | Yes                              | Yes                               | Pass   |
| No                               | Yes                             | No                               | No                                | Pass   |

#### Test setup:

To check the complete signalling sequence to open a car, the following hardware of the car is required:

- Door proximity sensor
- 013854 - LF KESSY IO box (incl. LF antennas)
- RSB19 -UWB ranging device
- BCM - Body Controller Module (contains a 434 UHF transceiver), connected via CAN-bus
- The CAR network is simulated by a VECTOR CAN simulation

#### Transmission time:

**Ambient temperature:** 24 °C  
**Air Pressure:** 1019 hPa  
**Humidity:** 31 %

| Operating Band: 3100 - 10600 MHz |                               |               |                      |                                     |            |                      |
|----------------------------------|-------------------------------|---------------|----------------------|-------------------------------------|------------|----------------------|
| Channel                          | Length of single impulse [µs] | No of impulse | Repetition rate [ms] | Total duration of transmission [ms] | Limit [ms] | Margin to Limit [ms] |
| Mid                              | 388.34                        | 5             | 1.57                 | 6.61                                | 10000.00   | 9993.39              |

Note: The timing behaviour is for all three channels identical.  
 Please see next chapter for measurement plots

### Signalling sequence – Associated receiver in range

#### WUP of the key is known by the BCM:

1. Touching the door proximity sensor initiates a LF transmission by the LF KESSY IO box
2. The EUT (FS19) receives the LF-message and checks if the signal comes from its associated vehicle, to which the EUT is “learned” to.
3. In case of an associated car, the key (EUT) answers on UHF 434 MHz. This signal is received by the BCM of the car. Here takes an additional cryptographical data exchange place.
4. If the BCM sends the correct data back to key (EUT), via UHF 434 MHz, the key initiates an UWB transmission. The signal is received by the RSB19. The RSB19 answers on the same frequency. With this signal exchange the distance between the key (EUT) and the car can be calculated.
5. If the calculated distance is below a defined threshold, the vehicle will be opened.

Please see the **diagram ASS1** of the complete radio transmission in the next chapter.

### Signalling sequence – No Associated receiver in range

#### WUP of the key is not known by the BCM:

1. Touching the door proximity sensor initiates a LF transmission by the LF KESSY IO box
2. The EUT (FS19) receives the LF-message and checks if the signal comes from its associated vehicle.
3. In case the LF request of a “wrong” vehicle will wakeup “accidentally” the UID, after the reception of the encrypted challenge from the BCM, the key will stop the function and will not send out any UWB or RF messages.
4. In case of a not-associated car, the stops any further RF transmission.  
No communication on UHF and UWB takes place. The EUT is in sleep mode again.

Please see the **diagram ASS2** of the complete radio transmission in the next chapter.

### Transmission Time setup

The transmission time checks the UWB behaviour of the FS197 if the RSB19 is switched off during the UWB transmission of the FS197. Because the transmission time of the complete system is too short, to switch-off the RSB19 manually, for this test a trigger circuitry was made between the FS197 and the RSB19. In both components the power on/off behaviour of a DC-DC converter, which controls the UWB TX/RX behaviour of the corresponding device was used for the trigger.

**Diagram TT1** shows the complete radio behaviour of the system in this test setup.

**Diagram TT2** is just a single view (for better readability) of the third plot in **Diagram TT1**. It shows in detail the UWB radio behaviour of the system. The FS197 sends the first pulse, the RSB19 acknowledges it. During the second pulse of the FS197, the RSB19 is switched off. The FS197 receives no acknowledge for its second pulse. The FS197 sends three additional pulses, which are also not acknowledged. Afterwards the FS197 ceases transmission. For the detailed UWB timing of this sequence please see **Diagram TT2**.

The **Diagram TT3** contains the timing of the trigger circuitry. It shows (together with **Diagram TT2**) the conjunction of the switch-off timing of the RSB19 and the UWB radio behavior. For the timing details and additional explanations, please see the text below

**Diagram TT3.**

**Diagram TT4** shows, that the transmission really ends after one pulse train.

### Conclusion:

The behavior of the FS197/RSB19 fulfills the requirements of FCC Part 15, Subpart F, §15.519 (a) (1) / RSS-220, 5.3.1 (b).

#### 4.7.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

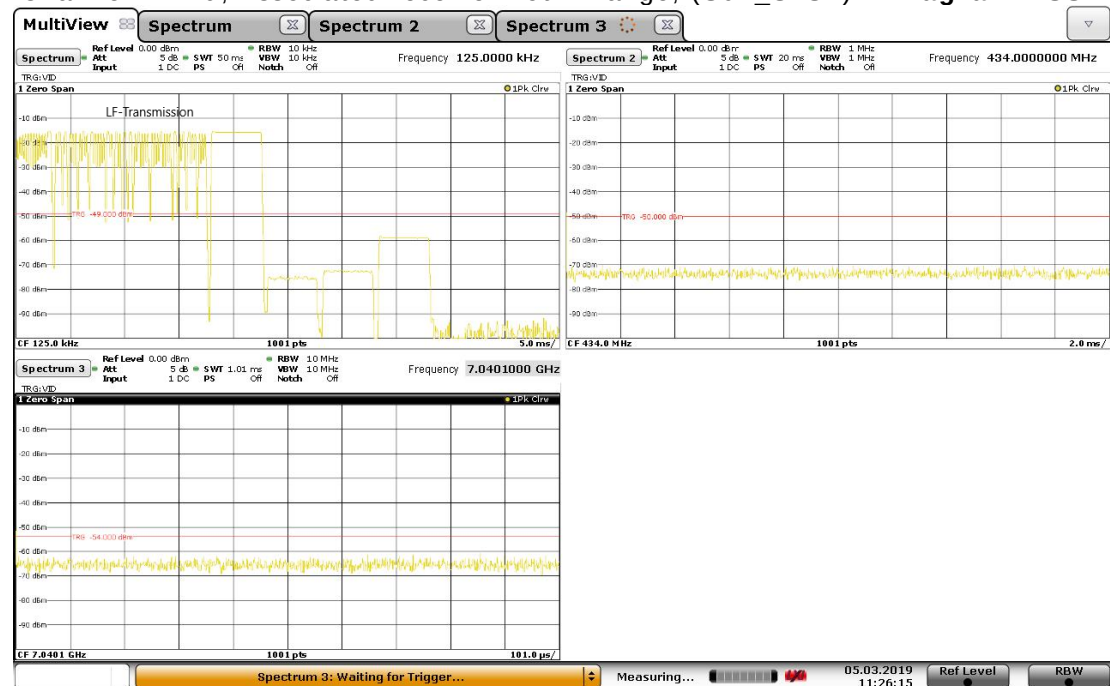
##### Associated Receiver:

Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Channel = mid, Associated receiver in range, (S01\_SYS1) – **Diagram ASS1**



11:15:32 05.03.2019

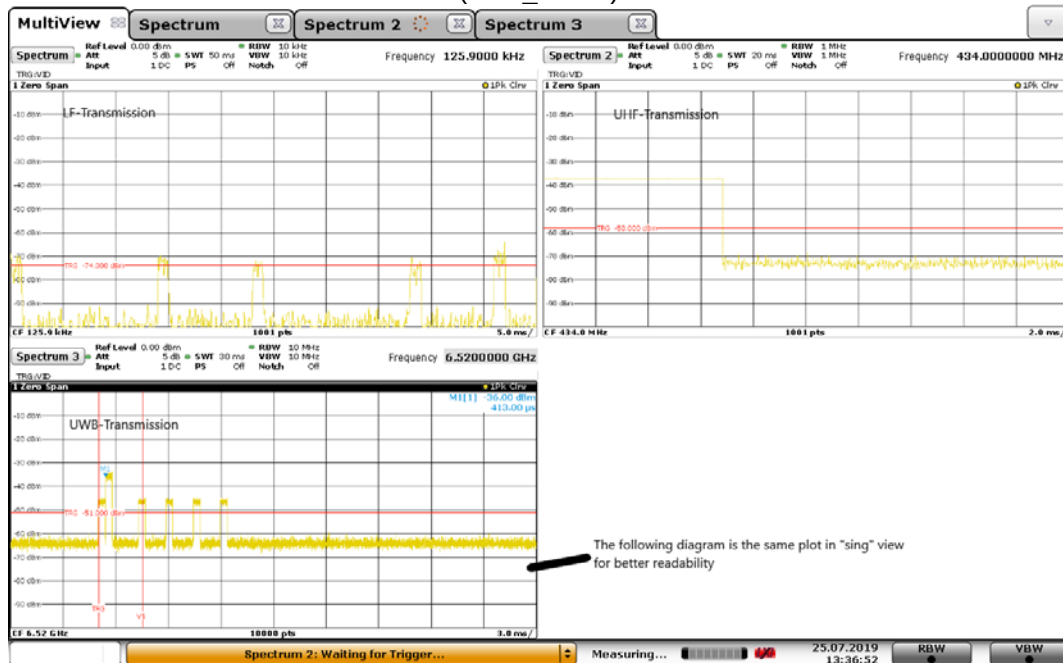
Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Channel = mid, Associated receiver not in range, (S01\_SYS2) – **Diagram ASS2**



11:26:15 05.03.2019

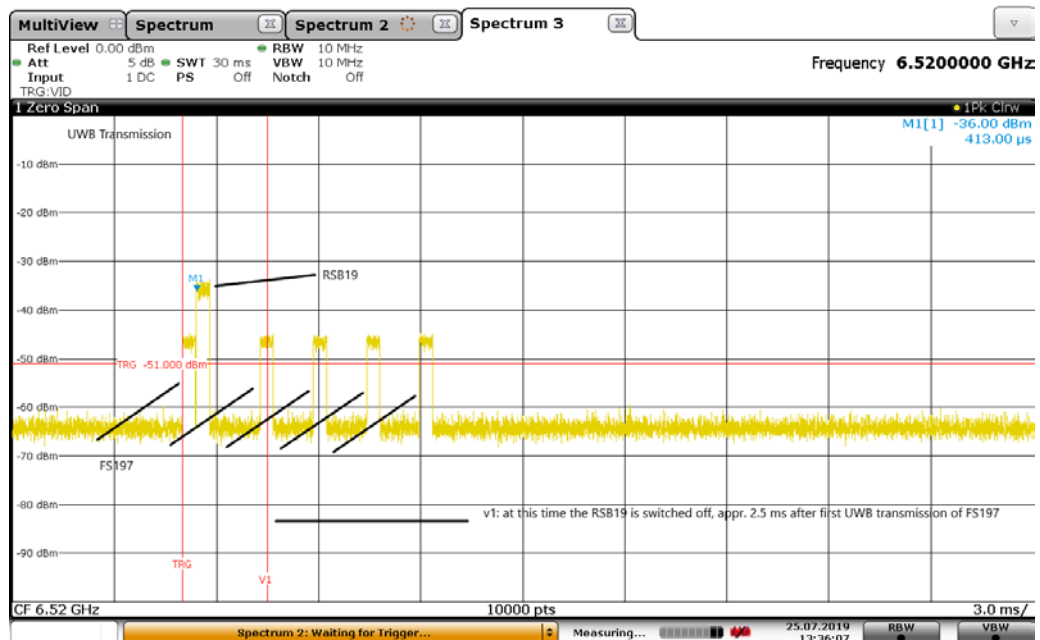
Transmission time:

Measurement method = radiated, Operating band = 3100 – 10600 MHz,  
Channel = low  
(S01\_SYS3)



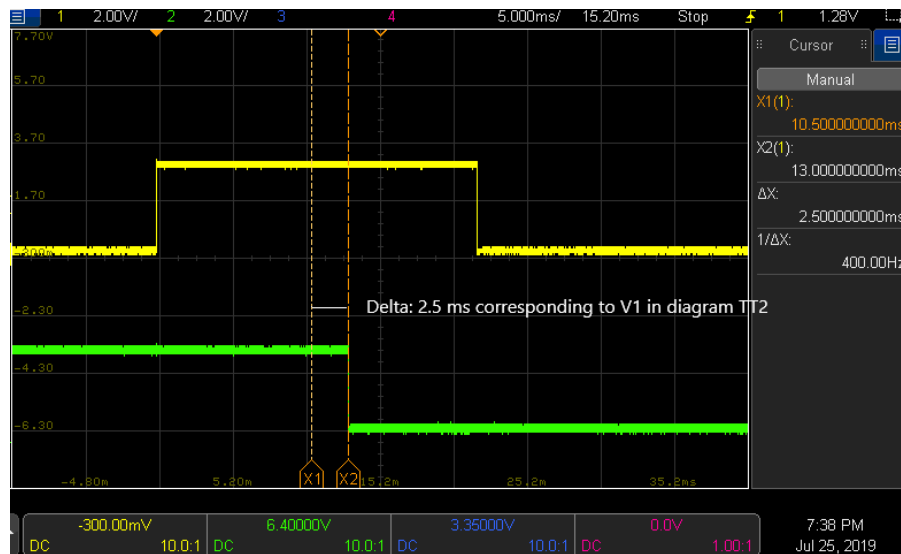
13:36:53 25.07.2019

Diagram TT1 - Complete radio transmission of the system



13:36:08 25.07.2019

Diagram TT2 - FS197 UWB behaviour after RSB19 switch-off



**Diagram TT3**

Timing diagram of RSB19 control;

- yellow curve: DC-DC converter of the FS197 → controls the UWB-power on/off of the FS197  
The delta between the “ramp-up” of the curve and cursor X1 and represents the time delay (appr. 10.5ms) between the power-on of the DC-DC converter and the first UWB transmission of the FS197
- green curve: DC-DC converter of the RSB19 → controls the UWB -power off/on of the RSB19  
The delta between the “ramp-down (X2)” of the curve and cursor X1 and represents the time delay between is the first UWB transmission of the FS197 and the UWB shut-down of the RSB19 (appr. 2.5 ms). Please compare to diagram TT2, Line V1



**Diagram TT4 – check for the 10 second limit**

#### 4.7.5 TEST EQUIPMENT USED

- ESW44

## 5 TEST EQUIPMENT

- 1 Conducted Emissions FCC  
Conducted Emissions power line for FCC standards

| Ref.No. | Device Name          | Description                                   | Manufacturer                      | Serial Number | Last Calibration | Calibration Due |
|---------|----------------------|-----------------------------------------------|-----------------------------------|---------------|------------------|-----------------|
| 1.1     | Opus10 TPR (8253.00) | ThermoAirpressure Datalogger 13 (Environ)     | Lufth Mess- und Regeltechnik GmbH | 13936         | 2017-04          | 2019-04         |
| 1.2     | Fluke 177            | Digital Multimeter 03 (Multimeter)            | Fluke Europe B.V.                 | 86670383      | 2018-04          | 2020-04         |
| 1.3     | ESH3-Z5              | Two-Line V-Network                            | Rohde & Schwarz                   | 828304/029    | 2017-05          | 2019-05         |
| 1.4     | EP 1200/B, NA/B1     | Amplifier with integrated variable Oscillator | Spitzenberger & Spieß             | B6278         |                  |                 |
| 1.5     | Chroma 6404          | AC Power Source                               | Chroma ATE INC.                   | 64040001304   |                  |                 |
| 1.6     | Shielded Room 02     | Shielded Room for conducted testing, 12qm     | Frankonia                         | -             |                  |                 |
| 1.7     | ESH3-Z5              | Two-Line V-Network                            | Rohde & Schwarz                   | 829996/002    | 2017-05          | 2019-05         |
| 1.8     | Opus10 THI (8152.00) | ThermoHygro Datalogger 02 (Environ)           | Lufth Mess- und Regeltechnik GmbH | 7489          | 2017-04          | 2019-04         |
| 1.9     | ESIB 26              | Spectrum Analyzer                             | Rohde & Schwarz                   | 830482/004    | 2018-01          | 2020-01         |

- 2 Radiated Emissions  
Lab to perform radiated emission tests

| Ref.No. | Device Name          | Description                               | Manufacturer                       | Serial Number | Last Calibration | Calibration Due |
|---------|----------------------|-------------------------------------------|------------------------------------|---------------|------------------|-----------------|
| 2.1     | NRV-Z1               | Sensor Head A                             | Rohde & Schwarz GmbH & Co. KG      | 827753/005    | 2018-07          | 2019-07         |
| 2.2     | MFS                  | Rubidium Frequency Normal MFS             | Datum GmbH                         | 002           | 2018-10          | 2020-10         |
| 2.3     | Opus10 TPR (8253.00) | ThermoAirpressure Datalogger 13 (Environ) | Lufth Mess- und Regeltechnik GmbH  | 13936         | 2017-04          | 2019-04         |
| 2.4     | ESW44                | EMI Test Receiver                         | Rohde & Schwarz GmbH & Co. KG      | 101603        | 2018-05          | 2019-05         |
| 2.5     | Anechoic Chamber     | 10.58 x 6.38 x 6.00 m <sup>3</sup>        | Frankonia                          | none          | 2018-06          | 2020-06         |
| 2.6     | FS-Z60               | Harmonic Mixer 40 - 60 GHz                | Rohde & Schwarz Messgerätebau GmbH | 100178        | 2016-12          | 2019-12         |
| 2.7     | FS-Z220              | Harmonic Mixer 140 - 220 GHz              | Rohde & Schwarz Messgerätebau GmbH | 101005        | 2017-03          | 2020-03         |

| Ref.No. | Device Name          | Description                                            | Manufacturer                       | Serial Number      | Last Calibration | Calibration Due |
|---------|----------------------|--------------------------------------------------------|------------------------------------|--------------------|------------------|-----------------|
| 2.8     | SGH-05               | Standard Gain / Pyramidal Horn Antenna (140 - 220 GHz) | RPG-Radiometer Physics GmbH        | 075                |                  |                 |
| 2.9     | HL 562               | Ultralog new biconicals                                | Rohde & Schwarz                    | 830547/003         | 2018-07          | 2021-07         |
| 2.10    | 5HC2700/12750-1.5-KK | High Pass Filter                                       | Trilithic                          | 9942012            |                  |                 |
| 2.11    | ASP 1.2/1.8-10 kg    | Antenna Mast                                           | Maturo GmbH                        | -                  |                  |                 |
| 2.12    | Fully Anechoic Room  | 8.80m x 4.60m x 4.05m (l x w x h)                      | Albatross Projects                 | P26971-647-001-PRB | 2018-06          | 2020-06         |
| 2.13    | Fluke 177            | Digital Multimeter 03 (Multimeter)                     | Fluke Europe B.V.                  | 86670383           | 2018-04          | 2020-04         |
| 2.14    | NRVD                 | Power Meter                                            | Rohde & Schwarz GmbH & Co. KG      | 828110/016         | 2018-07          | 2019-07         |
| 2.15    | HF 906               | Double-ridged horn                                     | Rohde & Schwarz                    | 357357/002         | 2018-09          | 2021-09         |
| 2.16    | JS4-18002600-32-5P   | Broadband Amplifier 18 GHz - 26 GHz                    | Miteq                              | 849785             |                  |                 |
| 2.17    | FSW 43               | Spectrum Analyzer                                      | Rohde & Schwarz                    | 103779             | 2016-12          | 2018-12         |
| 2.18    | 3160-09              | Standard Gain / Pyramidal Horn Antenna 26.5 GHz        | EMCO Elektronik GmbH               | 00083069           |                  |                 |
| 2.19    | SGH-19               | Standard Gain / Pyramidal Horn Antenna (40 - 60 GHz)   | RPG-Radiometer Physics GmbH        | 093                |                  |                 |
| 2.20    | WHKX 7.0/18G-8SS     | High Pass Filter                                       | Wainwright                         | 09                 |                  |                 |
| 2.21    | 4HC1600/12750-1.5-KK | High Pass Filter                                       | Trilithic                          | 9942011            |                  |                 |
| 2.22    | Chroma 6404          | AC Power Source                                        | Chroma ATE INC.                    | 64040001304        |                  |                 |
| 2.23    | JS4-00102600-42-5A   | Broadband Amplifier 30 MHz - 26 GHz                    | Miteq                              | 619368             |                  |                 |
| 2.24    | TT 1.5 WI            | Turn Table                                             | Maturo GmbH                        | -                  |                  |                 |
| 2.25    | HL 562 Ultralog      | Log.-per. Antenna                                      | Rohde & Schwarz                    | 100609             | 2016-04          | 2019-04         |
| 2.26    | HF 906               | Double-ridged horn                                     | Rohde & Schwarz                    | 357357/001         | 2018-03          | 2021-03         |
| 2.27    | FS-Z325              | Harmonic Mixer 220 - 325 GHz                           | Rohde & Schwarz Messgerätebau GmbH | 101006             | 2017-03          | 2020-03         |
| 2.28    | 3160-10              | Standard Gain / Pyramidal Horn Antenna 40 GHz          | EMCO Elektronik GmbH               | 00086675           |                  |                 |

| Ref.No. | Device Name                   | Description                                            | Manufacturer                       | Serial Number          | Last Calibration | Calibration Due |
|---------|-------------------------------|--------------------------------------------------------|------------------------------------|------------------------|------------------|-----------------|
| 2.29    | SGH-08                        | Standard Gain / Pyramidal Horn Antenna (90 - 140 GHz)  | RPG-Radiometer Physics GmbH        | 064                    |                  |                 |
| 2.30    | SGH-12                        | Standard Gain / Pyramidal HornAntenna (60 - 90 GHz)    | RPG-Radiometer Physics GmbH        | 326                    |                  |                 |
| 2.31    | 5HC3500/18000-1.2-KK          | High Pass Filter                                       | Trilithic                          | 200035008              |                  |                 |
| 2.32    | FS-Z140                       | Harmonic Mixer 90 -140 GHz                             | Rohde & Schwarz Messgerätebau GmbH | 101007                 | 2017-02          | 2020-02         |
| 2.33    | HFH2-Z2                       | Loop Antenna                                           | Rohde & Schwarz                    | 829324/006             | 2018-01          | 2021-01         |
| 2.34    | Opus10 THI (8152.00)          | ThermoHygro Datalogger 12 (Environ)                    | Lufft Mess- und Regeltechnik GmbH  | 12482                  | 2017-03          | 2019-03         |
| 2.35    | JS4-00101800-35-5P            | Broadband Amplifier 30 MHz - 18 GHz                    | Miteq                              | 896037                 |                  |                 |
| 2.36    | AS 620 P                      | Antenna mast                                           | HD GmbH                            | 620/37                 |                  |                 |
| 2.37    | Tilt device Maturo (Rohacell) | Antrieb TD1.5-10kg                                     | Maturo GmbH                        | TD1.5-10kg/024/3790709 |                  |                 |
| 2.38    | SGH-03                        | Standard Gain / Pyramidal Horn Antenna (220 - 325 GHz) | RPG-Radiometer Physics GmbH        | 060                    |                  |                 |
| 2.39    | FS-Z90                        | Harmonic Mixer 60 - 90 GHz                             | Rohde & Schwarz Messgerätebau GmbH | 101686                 | 2017-03          | 2020-03         |
| 2.40    | ESIB 26                       | Spectrum Analyzer                                      | Rohde & Schwarz                    | 830482/004             | 2018-01          | 2020-01         |
| 2.41    | PAS 2.5 - 10 kg               | Antenna Mast                                           | Maturo GmbH                        | -                      |                  |                 |
| 2.42    | AFS42-00101800-25-S-42        | Broadband Amplifier 25 MHz - 18 GHz                    | Miteq                              | 2035324                |                  |                 |
| 2.43    | AM 4.0                        | Antenna mast                                           | Maturo GmbH                        | AM4.0/180/11920513     |                  |                 |
| 2.44    | HF 907                        | Double-ridged horn                                     | Rohde & Schwarz                    | 102444                 | 2018-07          | 2021-07         |

The calibration interval is the time interval between “Last Calibration” and “Calibration Due”

## 6 ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

This chapter contains the antenna factors with their corresponding path loss of the used measurement path for all antennas as well as the insertion loss of the LISN.

### 6.1 LISN R&S ESH3-Z5 (150 KHZ – 30 MHZ)

| Frequency |  | Corr. | LISN<br>insertion<br>loss<br>ESH3-<br>Z5 | cable<br>loss<br>(incl. 10<br>dB<br>atten-<br>uator) |
|-----------|--|-------|------------------------------------------|------------------------------------------------------|
| MHz       |  | dB    | dB                                       | dB                                                   |
| 0.15      |  | 10.1  | 0.1                                      | 10.0                                                 |
| 5         |  | 10.3  | 0.1                                      | 10.2                                                 |
| 7         |  | 10.5  | 0.2                                      | 10.3                                                 |
| 10        |  | 10.5  | 0.2                                      | 10.3                                                 |
| 12        |  | 10.7  | 0.3                                      | 10.4                                                 |
| 14        |  | 10.7  | 0.3                                      | 10.4                                                 |
| 16        |  | 10.8  | 0.4                                      | 10.4                                                 |
| 18        |  | 10.9  | 0.4                                      | 10.5                                                 |
| 20        |  | 10.9  | 0.4                                      | 10.5                                                 |
| 22        |  | 11.1  | 0.5                                      | 10.6                                                 |
| 24        |  | 11.1  | 0.5                                      | 10.6                                                 |
| 26        |  | 11.2  | 0.5                                      | 10.7                                                 |
| 28        |  | 11.2  | 0.5                                      | 10.7                                                 |
| 30        |  | 11.3  | 0.5                                      | 10.8                                                 |

#### Sample calculation

$$U_{\text{LISN}} (\text{dB } \mu\text{V}) = U (\text{dB } \mu\text{V}) + \text{Corr. (dB)}$$

U = Receiver reading

LISN Insertion loss = Voltage Division Factor of LISN

Corr. = sum of single correction factors of used LISN, cables, switch units (if used)

Linear interpolation will be used for frequencies in between the values in the table.

## 6.2 ANTENNA R&S HFH2-Z2 (9 KHZ – 30 MHZ)

| Frequency | AF<br>HFH-Z2) | Corr. | cable<br>loss 1<br>(inside<br>chamber) | cable<br>loss 2<br>(outside<br>chamber) | cable<br>loss 3<br>(switch<br>unit) | cable<br>loss 4<br>(to<br>receiver) | distance<br>corr.<br>(-40 dB/<br>decade) | d <sub>Limit</sub><br>(meas.<br>distance<br>(limit)) | d <sub>used</sub><br>(meas.<br>distance<br>(used)) |
|-----------|---------------|-------|----------------------------------------|-----------------------------------------|-------------------------------------|-------------------------------------|------------------------------------------|------------------------------------------------------|----------------------------------------------------|
| MHz       | dB (1/m)      | dB    | dB                                     | dB                                      | dB                                  | dB                                  | dB                                       | m                                                    | m                                                  |
| 0.009     | 20.50         | -79.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -80                                      | 300                                                  | 3                                                  |
| 0.01      | 20.45         | -79.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -80                                      | 300                                                  | 3                                                  |
| 0.015     | 20.37         | -79.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -80                                      | 300                                                  | 3                                                  |
| 0.02      | 20.36         | -79.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -80                                      | 300                                                  | 3                                                  |
| 0.025     | 20.38         | -79.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -80                                      | 300                                                  | 3                                                  |
| 0.03      | 20.32         | -79.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -80                                      | 300                                                  | 3                                                  |
| 0.05      | 20.35         | -79.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -80                                      | 300                                                  | 3                                                  |
| 0.08      | 20.30         | -79.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -80                                      | 300                                                  | 3                                                  |
| 0.1       | 20.20         | -79.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -80                                      | 300                                                  | 3                                                  |
| 0.2       | 20.17         | -79.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -80                                      | 300                                                  | 3                                                  |
| 0.3       | 20.14         | -79.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -80                                      | 300                                                  | 3                                                  |
| 0.49      | 20.12         | -79.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -80                                      | 300                                                  | 3                                                  |
| 0.490001  | 20.12         | -39.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 0.5       | 20.11         | -39.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 0.8       | 20.10         | -39.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 1         | 20.09         | -39.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 2         | 20.08         | -39.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 3         | 20.06         | -39.6 | 0.1                                    | 0.1                                     | 0.1                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 4         | 20.05         | -39.5 | 0.2                                    | 0.1                                     | 0.1                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 5         | 20.05         | -39.5 | 0.2                                    | 0.1                                     | 0.1                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 6         | 20.02         | -39.5 | 0.2                                    | 0.1                                     | 0.1                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 8         | 19.95         | -39.5 | 0.2                                    | 0.1                                     | 0.1                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 10        | 19.83         | -39.4 | 0.2                                    | 0.1                                     | 0.2                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 12        | 19.71         | -39.4 | 0.2                                    | 0.1                                     | 0.2                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 14        | 19.54         | -39.4 | 0.2                                    | 0.1                                     | 0.2                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 16        | 19.53         | -39.3 | 0.3                                    | 0.1                                     | 0.2                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 18        | 19.50         | -39.3 | 0.3                                    | 0.1                                     | 0.2                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 20        | 19.57         | -39.3 | 0.3                                    | 0.1                                     | 0.2                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 22        | 19.61         | -39.3 | 0.3                                    | 0.1                                     | 0.2                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 24        | 19.61         | -39.3 | 0.3                                    | 0.1                                     | 0.2                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 26        | 19.54         | -39.3 | 0.3                                    | 0.1                                     | 0.2                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 28        | 19.46         | -39.2 | 0.3                                    | 0.1                                     | 0.3                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |
| 30        | 19.73         | -39.1 | 0.4                                    | 0.1                                     | 0.3                                 | 0.1                                 | -40                                      | 30                                                   | 3                                                  |

### Sample calculation

$E \text{ (dB } \mu\text{V/m)} = U \text{ (dB } \mu\text{V)} + AF \text{ (dB 1/m)} + Corr. \text{ (dB)}$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)

distance correction =  $-40 * \text{LOG} (d_{\text{Limit}} / d_{\text{used}})$

Linear interpolation will be used for frequencies in between the values in the table.

Table shows an extract of values

### 6.3 ANTENNA R&S HL562 (30 MHz – 1 GHz)

( $d_{\text{Limit}} = 3 \text{ m}$ )

| Frequency | AF<br>R&S<br>HL562 | Corr. |
|-----------|--------------------|-------|
| MHz       | dB (1/m)           | dB    |
| 30        | 18.6               | 0.6   |
| 50        | 6.0                | 0.9   |
| 100       | 9.7                | 1.2   |
| 150       | 7.9                | 1.6   |
| 200       | 7.6                | 1.9   |
| 250       | 9.5                | 2.1   |
| 300       | 11.0               | 2.3   |
| 350       | 12.4               | 2.6   |
| 400       | 13.6               | 2.9   |
| 450       | 14.7               | 3.1   |
| 500       | 15.6               | 3.2   |
| 550       | 16.3               | 3.5   |
| 600       | 17.2               | 3.5   |
| 650       | 18.1               | 3.6   |
| 700       | 18.5               | 3.6   |
| 750       | 19.1               | 4.1   |
| 800       | 19.6               | 4.1   |
| 850       | 20.1               | 4.4   |
| 900       | 20.8               | 4.7   |
| 950       | 21.1               | 4.8   |
| 1000      | 21.6               | 4.9   |

| cable<br>loss 1<br>(inside<br>chamber) | cable<br>loss 2<br>(outside<br>chamber) | cable<br>loss 3<br>(switch<br>unit) | cable<br>loss 4<br>(to<br>receiver) | distance<br>corr.<br>(-20 dB/<br>decade) | $d_{\text{Limit}}$<br>(meas.<br>distance<br>(limit)) | $d_{\text{used}}$<br>(meas.<br>distance<br>(used)) |
|----------------------------------------|-----------------------------------------|-------------------------------------|-------------------------------------|------------------------------------------|------------------------------------------------------|----------------------------------------------------|
| dB                                     | dB                                      | dB                                  | dB                                  | dB                                       | m                                                    | m                                                  |
| 0.29                                   | 0.04                                    | 0.23                                | 0.02                                | 0.0                                      | 3                                                    | 3                                                  |
| 0.39                                   | 0.09                                    | 0.32                                | 0.08                                | 0.0                                      | 3                                                    | 3                                                  |
| 0.56                                   | 0.14                                    | 0.47                                | 0.08                                | 0.0                                      | 3                                                    | 3                                                  |
| 0.73                                   | 0.20                                    | 0.59                                | 0.12                                | 0.0                                      | 3                                                    | 3                                                  |
| 0.84                                   | 0.21                                    | 0.70                                | 0.11                                | 0.0                                      | 3                                                    | 3                                                  |
| 0.98                                   | 0.24                                    | 0.80                                | 0.13                                | 0.0                                      | 3                                                    | 3                                                  |
| 1.04                                   | 0.26                                    | 0.89                                | 0.15                                | 0.0                                      | 3                                                    | 3                                                  |
| 1.18                                   | 0.31                                    | 0.96                                | 0.13                                | 0.0                                      | 3                                                    | 3                                                  |
| 1.28                                   | 0.35                                    | 1.03                                | 0.19                                | 0.0                                      | 3                                                    | 3                                                  |
| 1.39                                   | 0.38                                    | 1.11                                | 0.22                                | 0.0                                      | 3                                                    | 3                                                  |
| 1.44                                   | 0.39                                    | 1.20                                | 0.19                                | 0.0                                      | 3                                                    | 3                                                  |
| 1.55                                   | 0.46                                    | 1.24                                | 0.23                                | 0.0                                      | 3                                                    | 3                                                  |
| 1.59                                   | 0.43                                    | 1.29                                | 0.23                                | 0.0                                      | 3                                                    | 3                                                  |
| 1.67                                   | 0.34                                    | 1.35                                | 0.22                                | 0.0                                      | 3                                                    | 3                                                  |
| 1.67                                   | 0.42                                    | 1.41                                | 0.15                                | 0.0                                      | 3                                                    | 3                                                  |
| 1.87                                   | 0.54                                    | 1.46                                | 0.25                                | 0.0                                      | 3                                                    | 3                                                  |
| 1.90                                   | 0.46                                    | 1.51                                | 0.25                                | 0.0                                      | 3                                                    | 3                                                  |
| 1.99                                   | 0.60                                    | 1.56                                | 0.27                                | 0.0                                      | 3                                                    | 3                                                  |
| 2.14                                   | 0.60                                    | 1.63                                | 0.29                                | 0.0                                      | 3                                                    | 3                                                  |
| 2.22                                   | 0.60                                    | 1.66                                | 0.33                                | 0.0                                      | 3                                                    | 3                                                  |
| 2.23                                   | 0.61                                    | 1.71                                | 0.30                                | 0.0                                      | 3                                                    | 3                                                  |

( $d_{\text{Limit}} = 10 \text{ m}$ )

|      |      |      |
|------|------|------|
| 30   | 18.6 | -9.9 |
| 50   | 6.0  | -9.6 |
| 100  | 9.7  | -9.2 |
| 150  | 7.9  | -8.8 |
| 200  | 7.6  | -8.6 |
| 250  | 9.5  | -8.3 |
| 300  | 11.0 | -8.1 |
| 350  | 12.4 | -7.9 |
| 400  | 13.6 | -7.6 |
| 450  | 14.7 | -7.4 |
| 500  | 15.6 | -7.2 |
| 550  | 16.3 | -7.0 |
| 600  | 17.2 | -6.9 |
| 650  | 18.1 | -6.9 |
| 700  | 18.5 | -6.8 |
| 750  | 19.1 | -6.3 |
| 800  | 19.6 | -6.3 |
| 850  | 20.1 | -6.0 |
| 900  | 20.8 | -5.8 |
| 950  | 21.1 | -5.6 |
| 1000 | 21.6 | -5.6 |

|      |      |      |      |       |    |   |
|------|------|------|------|-------|----|---|
| 0.29 | 0.04 | 0.23 | 0.02 | -10.5 | 10 | 3 |
| 0.39 | 0.09 | 0.32 | 0.08 | -10.5 | 10 | 3 |
| 0.56 | 0.14 | 0.47 | 0.08 | -10.5 | 10 | 3 |
| 0.73 | 0.20 | 0.59 | 0.12 | -10.5 | 10 | 3 |
| 0.84 | 0.21 | 0.70 | 0.11 | -10.5 | 10 | 3 |
| 0.98 | 0.24 | 0.80 | 0.13 | -10.5 | 10 | 3 |
| 1.04 | 0.26 | 0.89 | 0.15 | -10.5 | 10 | 3 |
| 1.18 | 0.31 | 0.96 | 0.13 | -10.5 | 10 | 3 |
| 1.28 | 0.35 | 1.03 | 0.19 | -10.5 | 10 | 3 |
| 1.39 | 0.38 | 1.11 | 0.22 | -10.5 | 10 | 3 |
| 1.44 | 0.39 | 1.20 | 0.19 | -10.5 | 10 | 3 |
| 1.55 | 0.46 | 1.24 | 0.23 | -10.5 | 10 | 3 |
| 1.59 | 0.43 | 1.29 | 0.23 | -10.5 | 10 | 3 |
| 1.67 | 0.34 | 1.35 | 0.22 | -10.5 | 10 | 3 |
| 1.67 | 0.42 | 1.41 | 0.15 | -10.5 | 10 | 3 |
| 1.87 | 0.54 | 1.46 | 0.25 | -10.5 | 10 | 3 |
| 1.90 | 0.46 | 1.51 | 0.25 | -10.5 | 10 | 3 |
| 1.99 | 0.60 | 1.56 | 0.27 | -10.5 | 10 | 3 |
| 2.14 | 0.60 | 1.63 | 0.29 | -10.5 | 10 | 3 |
| 2.22 | 0.60 | 1.66 | 0.33 | -10.5 | 10 | 3 |
| 2.23 | 0.61 | 1.71 | 0.30 | -10.5 | 10 | 3 |

#### Sample calculation

$E \text{ (dB } \mu\text{V/m)} = U \text{ (dB } \mu\text{V)} + \text{AF (dB 1/m)} + \text{Corr. (dB)}$   
 $U$  = Receiver reading  
 $\text{AF}$  = Antenna factor  
 $\text{Corr.}$  = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)  
 $\text{distance correction} = -20 \cdot \text{LOG} (d_{\text{Limit}} / d_{\text{used}})$   
 Linear interpolation will be used for frequencies in between the values in the table.  
 Tables show an extract of values.

#### 6.4 ANTENNA R&S HF907 (1 GHZ – 18 GHZ)

| Frequency | AF<br>R&S<br>HF907 | Corr. |
|-----------|--------------------|-------|
| MHz       | dB (1/m)           | dB    |
| 1000      | 24.4               | -19.4 |
| 2000      | 28.5               | -17.4 |
| 3000      | 31.0               | -16.1 |
| 4000      | 33.1               | -14.7 |
| 5000      | 34.4               | -13.7 |
| 6000      | 34.7               | -12.7 |
| 7000      | 35.6               | -11.0 |

| cable<br>loss 1<br>(relay +<br>cable<br>inside<br>chamber) | cable<br>loss 2<br>(outside<br>chamber) | cable<br>loss 3<br>(switch<br>unit,<br>atten-<br>uator &<br>pre-amp) | cable<br>loss 4 (to<br>receiver) |  |  |
|------------------------------------------------------------|-----------------------------------------|----------------------------------------------------------------------|----------------------------------|--|--|
| dB                                                         | dB                                      | dB                                                                   | dB                               |  |  |
| 0.99                                                       | 0.31                                    | -21.51                                                               | 0.79                             |  |  |
| 1.44                                                       | 0.44                                    | -20.63                                                               | 1.38                             |  |  |
| 1.87                                                       | 0.53                                    | -19.85                                                               | 1.33                             |  |  |
| 2.41                                                       | 0.67                                    | -19.13                                                               | 1.31                             |  |  |
| 2.78                                                       | 0.86                                    | -18.71                                                               | 1.40                             |  |  |
| 2.74                                                       | 0.90                                    | -17.83                                                               | 1.47                             |  |  |
| 2.82                                                       | 0.86                                    | -16.19                                                               | 1.46                             |  |  |

| Frequency | AF<br>R&S<br>HF907 | Corr. |
|-----------|--------------------|-------|
| MHz       | dB (1/m)           | dB    |
| 3000      | 31.0               | -23.4 |
| 4000      | 33.1               | -23.3 |
| 5000      | 34.4               | -21.7 |
| 6000      | 34.7               | -21.2 |
| 7000      | 35.6               | -19.8 |

| cable<br>loss 1<br>(relay<br>inside<br>chamber) | cable<br>loss 2<br>(inside<br>chamber) | cable<br>loss 3<br>(outside<br>chamber) | cable<br>loss 4<br>(switch<br>unit,<br>atten-<br>uator &<br>pre-amp) | cable<br>loss 5 (to<br>receiver) | used<br>for<br>FCC<br>15.247 |
|-------------------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------------------|----------------------------------|------------------------------|
| dB                                              | dB                                     | dB                                      | dB                                                                   | dB                               |                              |
| 0.47                                            | 1.87                                   | 0.53                                    | -27.58                                                               | 1.33                             |                              |
| 0.56                                            | 2.41                                   | 0.67                                    | -28.23                                                               | 1.31                             |                              |
| 0.61                                            | 2.78                                   | 0.86                                    | -27.35                                                               | 1.40                             |                              |
| 0.58                                            | 2.74                                   | 0.90                                    | -26.89                                                               | 1.47                             |                              |
| 0.66                                            | 2.82                                   | 0.86                                    | -25.58                                                               | 1.46                             |                              |

| Frequency | AF<br>R&S<br>HF907 | Corr. |
|-----------|--------------------|-------|
| MHz       | dB (1/m)           | dB    |
| 7000      | 35.6               | -57.3 |
| 8000      | 36.3               | -56.3 |
| 9000      | 37.1               | -55.3 |
| 10000     | 37.5               | -56.2 |
| 11000     | 37.5               | -55.3 |
| 12000     | 37.6               | -53.7 |
| 13000     | 38.2               | -53.5 |
| 14000     | 39.9               | -56.3 |
| 15000     | 40.9               | -54.1 |
| 16000     | 41.3               | -54.1 |
| 17000     | 42.8               | -54.4 |
| 18000     | 44.2               | -54.7 |

| cable<br>loss 1<br>(relay<br>inside<br>chamber) | cable<br>loss 2<br>(High<br>Pass) | cable<br>loss 3<br>(pre-<br>amp) | cable<br>loss 4<br>(inside<br>chamber) | cable<br>loss 5<br>(outside<br>chamber) | cable<br>loss 6<br>(to<br>receiver) |
|-------------------------------------------------|-----------------------------------|----------------------------------|----------------------------------------|-----------------------------------------|-------------------------------------|
| dB                                              | dB                                | dB                               | dB                                     | dB                                      | dB                                  |
| 0.56                                            | 1.28                              | -62.72                           | 2.66                                   | 0.94                                    | 1.46                                |
| 0.69                                            | 0.71                              | -61.49                           | 2.84                                   | 1.00                                    | 1.53                                |
| 0.68                                            | 0.65                              | -60.80                           | 3.06                                   | 1.09                                    | 1.60                                |
| 0.70                                            | 0.54                              | -61.91                           | 3.28                                   | 1.20                                    | 1.67                                |
| 0.80                                            | 0.61                              | -61.40                           | 3.43                                   | 1.27                                    | 1.70                                |
| 0.84                                            | 0.42                              | -59.70                           | 3.53                                   | 1.26                                    | 1.73                                |
| 0.83                                            | 0.44                              | -59.81                           | 3.75                                   | 1.32                                    | 1.83                                |
| 0.91                                            | 0.53                              | -63.03                           | 3.91                                   | 1.40                                    | 1.77                                |
| 0.98                                            | 0.54                              | -61.05                           | 4.02                                   | 1.44                                    | 1.83                                |
| 1.23                                            | 0.49                              | -61.51                           | 4.17                                   | 1.51                                    | 1.85                                |
| 1.36                                            | 0.76                              | -62.36                           | 4.34                                   | 1.53                                    | 2.00                                |
| 1.70                                            | 0.53                              | -62.88                           | 4.41                                   | 1.55                                    | 1.91                                |

#### Sample calculation

$$E \text{ (dB } \mu\text{V/m)} = U \text{ (dB } \mu\text{V)} + AF \text{ (dB 1/m)} + Corr. \text{ (dB)}$$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)

Linear interpolation will be used for frequencies in between the values in the table.

Tables show an extract of values.

## 6.5 ANTENNA EMCO 3160-09 (18 GHZ – 26.5 GHZ)

| Frequency | AF<br>EMCO<br>3160-09 | Corr. | cable<br>loss 1<br>(inside<br>chamber) | cable<br>loss 2<br>(pre-<br>amp) | cable<br>loss 3<br>(inside<br>chamber) | cable<br>loss 4<br>(switch<br>unit) | cable<br>loss 5<br>(to<br>receiver) |
|-----------|-----------------------|-------|----------------------------------------|----------------------------------|----------------------------------------|-------------------------------------|-------------------------------------|
| MHz       | dB (1/m)              | dB    | dB                                     | dB                               | dB                                     | dB                                  | dB                                  |
| 18000     | 40.2                  | -23.5 | 0.72                                   | -35.85                           | 6.20                                   | 2.81                                | 2.65                                |
| 18500     | 40.2                  | -23.2 | 0.69                                   | -35.71                           | 6.46                                   | 2.76                                | 2.59                                |
| 19000     | 40.2                  | -22.0 | 0.76                                   | -35.44                           | 6.69                                   | 3.15                                | 2.79                                |
| 19500     | 40.3                  | -21.3 | 0.74                                   | -35.07                           | 7.04                                   | 3.11                                | 2.91                                |
| 20000     | 40.3                  | -20.3 | 0.72                                   | -34.49                           | 7.30                                   | 3.07                                | 3.05                                |
| 20500     | 40.3                  | -19.9 | 0.78                                   | -34.46                           | 7.48                                   | 3.12                                | 3.15                                |
| 21000     | 40.3                  | -19.1 | 0.87                                   | -34.07                           | 7.61                                   | 3.20                                | 3.33                                |
| 21500     | 40.3                  | -19.1 | 0.90                                   | -33.96                           | 7.47                                   | 3.28                                | 3.19                                |
| 22000     | 40.3                  | -18.7 | 0.89                                   | -33.57                           | 7.34                                   | 3.35                                | 3.28                                |
| 22500     | 40.4                  | -19.0 | 0.87                                   | -33.66                           | 7.06                                   | 3.75                                | 2.94                                |
| 23000     | 40.4                  | -19.5 | 0.88                                   | -33.75                           | 6.92                                   | 3.77                                | 2.70                                |
| 23500     | 40.4                  | -19.3 | 0.90                                   | -33.35                           | 6.99                                   | 3.52                                | 2.66                                |
| 24000     | 40.4                  | -19.8 | 0.88                                   | -33.99                           | 6.88                                   | 3.88                                | 2.58                                |
| 24500     | 40.4                  | -19.5 | 0.91                                   | -33.89                           | 7.01                                   | 3.93                                | 2.51                                |
| 25000     | 40.4                  | -19.3 | 0.88                                   | -33.00                           | 6.72                                   | 3.96                                | 2.14                                |
| 25500     | 40.5                  | -20.4 | 0.89                                   | -34.07                           | 6.90                                   | 3.66                                | 2.22                                |
| 26000     | 40.5                  | -21.3 | 0.86                                   | -35.11                           | 7.02                                   | 3.69                                | 2.28                                |
| 26500     | 40.5                  | -21.1 | 0.90                                   | -35.20                           | 7.15                                   | 3.91                                | 2.36                                |

### Sample calculation

$E \text{ (dB } \mu\text{V/m)} = U \text{ (dB } \mu\text{V)} + AF \text{ (dB 1/m)} + Corr. \text{ (dB)}$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)

Linear interpolation will be used for frequencies in between the values in the table.

Table shows an extract of values.

## 6.6 ANTENNA EMCO 3160-10 (26.5 GHZ – 40 GHZ)

| Frequency | AF<br>EMCO<br>3160-10 | Corr. | cable<br>loss 1<br>(inside<br>chamber) | cable<br>loss 2<br>(outside<br>chamber) | cable<br>loss 3<br>(switch<br>unit) | cable<br>loss 4<br>(to<br>receiver) | distance<br>corr.<br>(-20 dB/<br>decade) | d <sub>Limit</sub><br>(meas.<br>distance<br>(limit)) | d <sub>used</sub><br>(meas.<br>distance<br>(used)) |
|-----------|-----------------------|-------|----------------------------------------|-----------------------------------------|-------------------------------------|-------------------------------------|------------------------------------------|------------------------------------------------------|----------------------------------------------------|
| GHz       | dB (1/m)              | dB    | dB                                     | dB                                      | dB                                  | dB                                  | dB                                       | m                                                    | m                                                  |
| 26.5      | 43.4                  | -11.2 | 4.4                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 27.0      | 43.4                  | -11.2 | 4.4                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 28.0      | 43.4                  | -11.1 | 4.5                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 29.0      | 43.5                  | -11.0 | 4.6                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 30.0      | 43.5                  | -10.9 | 4.7                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 31.0      | 43.5                  | -10.8 | 4.7                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 32.0      | 43.5                  | -10.7 | 4.8                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 33.0      | 43.6                  | -10.7 | 4.9                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 34.0      | 43.6                  | -10.6 | 5.0                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 35.0      | 43.6                  | -10.5 | 5.1                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 36.0      | 43.6                  | -10.4 | 5.1                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 37.0      | 43.7                  | -10.3 | 5.2                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 38.0      | 43.7                  | -10.2 | 5.3                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 39.0      | 43.7                  | -10.2 | 5.4                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |
| 40.0      | 43.8                  | -10.1 | 5.5                                    |                                         |                                     |                                     | -15.6                                    | 3                                                    | 0.5                                                |

### Sample calculation

$E \text{ (dB } \mu\text{V/m)} = U \text{ (dB } \mu\text{V)} + AF \text{ (dB 1/m)} + Corr. \text{ (dB)}$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)

Linear interpolation will be used for frequencies in between the values in the table.

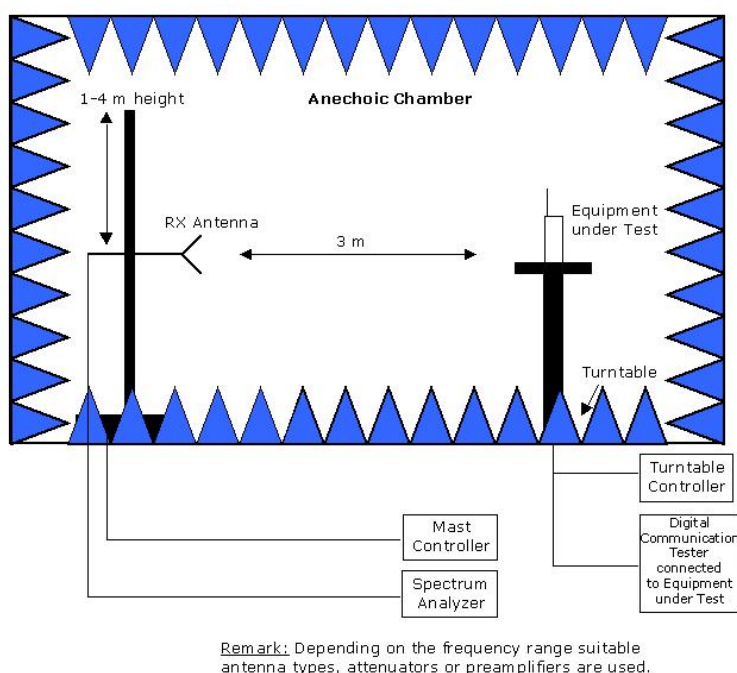
distance correction =  $-20 * \text{LOG} (d_{\text{Limit}} / d_{\text{used}})$

Linear interpolation will be used for frequencies in between the values in the table.

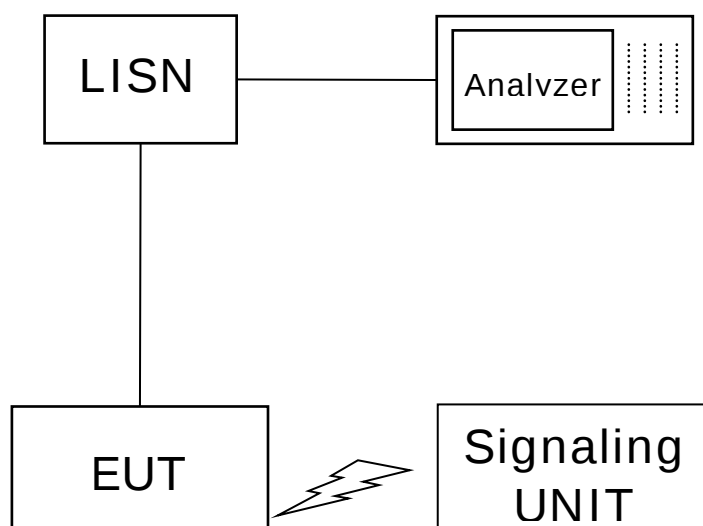
Table shows an extract of values.

## 7 SETUP DRAWINGS

### Setup Drawings



Setup in the Anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting ground plane.



Setup in the shielded room for conducted measurements at AC mains port

## 8 MEASUREMENT UNCERTAINTIES

| Test Case                       | Parameter      | Uncertainty  |
|---------------------------------|----------------|--------------|
| Conducted Emissions at AC mains | Voltage        | $\pm 3.4$ dB |
| Radiated Emissions              | Field Strength | $\pm 5.5$ dB |

## 9 PHOTO REPORT

Please see separate photo report.