InterLab

# FCC Measurement/Technical Report on

# TOBY-L201 UMTS/HSPA/LTE Data Module

FCC ID XPYTOBYL201
IC: 8595A-TOBYL201

**Report Reference:** MDE_UBLOX_1502_FCCb_rev1

according to FCC Part 22, Subpart H

**Test Laboratory:**
7Layers AG
Borsigstrasse 11
40880 Ratingen
Germany

DAkkS Deutsche Akkreditierungsstelle D-PL-12140-01-01

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# 0 Summary

## 0.1 Technical Report Summary

**Type of Authorization**
Certification for a GSM/WCDMA/LTE cellular radiotelephone device. This report covers only the LTE portion of this device.

**Applicable FCC Rules**

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 0 to 69. The following subparts are applicable to the results in this test report.

Part 2, Subpart J - Equipment Authorization Procedures, Certification

§ 2.1046 Measurement required: RF power output
§ 2.1049 Measurement required: Occupied bandwidth
§ 2.1051 Measurement required: Spurious emissions at antenna terminals
§ 2.1053 Measurement required: Field strength of spurious radiation
§ 2.1055 Measurement required: Frequency stability
§ 2.1057 Frequency spectrum to be investigated

Part 22, Subpart C – Operational and Technical Requirements

§ 22.355 Frequency tolerance

Part 22, Subpart H – Cellular Radiotelephone Service

§ 22.913 Effective radiated power limits
§ 22.917 Emission limitations for cellular equipment

Additional documents

Note:

ANSI TIA-603-C-2004

# Correlation of measurement requirements for Cellular Equipment from FCC and IC

| FCC Rule / IC Standard | Part 22 / RSS-132 | | Part 24 / RSS-133 (NA) | | Part 27 / RSS-139 / RSS-199 | | |
|---|---|---|---|---|---|---|---|
| Effective (isotropic) Radiated Power | §2.1046 §22.913 | RSS-GEN, §4.8 RSS-132, §5.4 | §2.1046 §24.232 | RSS-GEN, §4.8 RSS-133, §6.4 | §2.1046 §27.50 (d) | RSS-GEN, §4.8 RSS-139; §6.4 | RSS-GEN, §4.8 RSS-199; §4.4 |
| Occupied Bandwidth | §2.1049 | RSS-GEN §4.6 | §2.1049 | RSS-GEN §4.6 | §2.1049 | RSS-GEN §4.6 | RSS-GEN §4.6 |
| "Spuri" at Antenna Terminal | §2.1051 §22.917 | RSS-GEN, §4.9 RSS-132, §5.5 | §2.1051 §24.238 | RSS-GEN, §4.9 RSS-132, §6.5 | §2.1051 §27.5 (h) | RSS-GEN, §4.9 RSS-139, §6.5 | RSS-GEN, §4.9 RSS-199, §4.6 |
| Band Edge compliance | §2.1051 §22.917 | RSS-GEN, §4.6 | §2.1051 §24.238 | RSS-GEN, §4.6 | §2.1051 §27.5 (h) | RSS-GEN, §4.6 | RSS-GEN, §4.6 |
| Frequency Stability | §2.1055 §22.355 | RSS-GEN, §4.7 | §2.1055 §24.235 | RSS-GEN, §4.7 RSS-132, §6.3 | §2.1055 §27.51 | RSS-GEN, §4.7 RSS-139, §6.3 | RSS-GEN, §4.7 RSS-199, §4.3 |
| Peak to Average Ration | N/A | RSS-132, §5.3 | §2.1046 §24.232 | RSS-133, §6.4 | §2.1046 §27.50 (d) | RSS-139, §6.4 | NA |
| Modulation Characteristics | §2.1047 | RSS-132, §5.4 | §2.1047 | RSS-133, §6.2 | §2.1047 | RSS-139, §6.2 | RSS-199, §4.1 |
| Field Strength of Spurious Radiation | §2.1053 §22.917 | RSS-132, §5.2 | §2.1053 §24.235 | RSS-GEN, §4.9 RSS-133, §6.5 | §2.1053 §27.51 | RSS-GEN, §4.9 RSS-139, §6.5 | RSS-GEN, §4.9 RSS-199, §4.6 |

*) Receivers which are part of Transceivers are exempted with respect to Notice 2012-DRS0126.

**Summary Test Results:**

**The EUT complied with all performed tests as listed in chapter 0.2 Measurement Summary.**

## 0.2 Measurement Summary

| **FCC Part 22, Subpart H** | **§2.1046, §22.913** | |
|---|---|---|
| RF Power Output | | |
| **Setup** | **Port** | **Final Result** |
| Setup_01 | Temp.ant.connector | passed<br>2015-03-12 |
| **FCC Part 22, Subpart H** | **§2.1055** | |
| Frequency stability | | |
| **Setup** | **Port** | **Final Result** |
| Setup_02 | Temp.ant.connector | passed<br>2015-03-27 |
| **FCC Part 22, Subpart H** | **§2.1051, §22.917** | |
| Spurious emissions at antenna terminals | | |
| **Setup** | **Port** | **Final Result** |
| Setup_02 | Temp.ant.connector | passed<br>2015-04-02 |
| **FCC Part 22, Subpart H** | **§2.1049, §22.917** | |
| Emission and Occupied Bandwidth | | |
| **Setup** | **Port** | **Final Result** |
| Setup_01 | Temp.ant.connector | passed<br>2015-03-11 |
| **FCC Part 22, Subpart H** | **§2.1053, §22.917** | |
| Band edge compliance | | |
| **Setup** | **Port** | **Final Result** |
| Setup_03 | Temp.ant.connector | passed<br>2015-03-18 |
| **FCC Part 22, Subpart H , RSS-132 Issue 5** | **§5.4, §22.913** | |
| Peak-Average Ratio | | |
| **Setup** | **Port** | **Final Result** |
| Setup_01 | Temp.ant.connector | passed<br>2015-03-13 |
| **FCC Part 22, Subpart H** | **§2.1046, §22.917** | |
| Field strength of spurious radiation | | |
| **Setup** | **Port** | **Final Result** |
| Setup_02/03/04<br>1) | Enclosure | Passed<br>2015-05-14 |

1) Run of the complete frequency range, Setup_02 high and low channel, Setup_03 mid channel, spot checks Setup_04.

The current HW and SW versions of the module are: HW 218A03 SW 09.87. The tests were performed with an older SW and HW version, see DUT description. According to the information provided by the applicant, changes have only been made to Hard- and Software related to bands not covered by this report, so no additional testing was performed

Responsible for Accreditation Scope: MARCO KULLIK 2015.06.10 18:33:19 +02'00'

Responsible for Test Report: DANIEL GALL 2015.06.10 18:29:10 +02'00'

## Revision History

| Report version control | | | |
|---|---|---|---|
| **Version** | **Release date** | **Change Description** | **Version validity** |
| initial | 2015-05-29 | -- | invalid |
| rev1 | 2015-06-10 | Extended Test Description testcase Field strength of spurious radiation | valid |

# 1 Administrative Data

## 1.1 Testing Laboratory

| | |
|---|---|
| Company Name: | 7Layers AG |
| Address | Borsigstr. 11<br>40880 Ratingen<br>Germany |

This facility has been fully described in a report submitted to the FCC and accepted under the registration number 96716.

The test facility is also accredited by the following accreditation organisation:

| | |
|---|---|
| Laboratory accreditation no.: | DAkkS D-PL-12140-01-01 |
| Responsible for Accreditation Scope: | Dipl.-Ing. Bernhard Retka<br>Dipl.-Ing. Robert Machulec<br>Dipl.-Ing. Thomas Hoell<br>Dipl.-Ing. Marco Kullik<br>Dipl.-Ing. Andreas Petz |
| Report Template Version: | 2014-09-18 |

## 1.2 Project Data

| | |
|---|---|
| Responsible for testing and report: | Dipl.-Ing. Daniel Gall |
| Date of Test(s): | 2015-03-11 to 2015-05-14 |
| Date of Report: | 2015-06-10 |

## 1.3 Applicant Data

| | |
|---|---|
| Company Name: | u-blox AG |
| Address: | Zürcherstrasse 68,<br>CH-8800 Thalwil<br>Switzerland |
| Contact Person: | Mr. Giulio Comar |
| Phone: | +41 44 722 7462 |
| Email Address: | giulio.comar@u-blox.com |

## 1.4 Manufacturer Data

| | |
|---|---|
| Company Name: | please see applicant data |
| Address: | |
| Contact Person: | |

# 2 Test object Data

## 2.1 General EUT Description

| | |
|---|---|
| **Equipment under Test:** | UMTS/HSPA/LTE Data Module |
| **Type Designation:** | TOBY-L201 |
| **Kind of Device:** | Module |
| **(optional)** | |
| **Voltage Type:** | DC |
| **Voltage Level:** | 3.8 V |
| **Tested Modulation Type:** | QPSK;16QAM |

**General product description:**

The Module is able to operating in the following bands:
UMTS/HSDPA/HSUPA FDD II, V
LTE eFDD 2, 4, 5, 13 and 17

**The EUT provides the following ports:**

**Ports**
Temporary antenna connector
Enclosure

## 2.2 EUT Main components

### Type, S/N, Short Descriptions etc. used in this Test Report

| Short Description | Equipment under Test | Type Designation | Serial No. | HW Status | SW Status |
|---|---|---|---|---|---|
| EUT A (Code: DE1015014aa01) | UMTS/LTE Module | TOBY-L201 | 358502060012807 | 218A02 | 09.81 |
| EUT B (Code: DE1015014aa02) | UMTS/LTE Module | TOBY-L201 | 358502060012807 | 218A02 | 09.82 |
| EUT C (Code: DE1015014ae01) | UMTS/LTE Module | TOBY-L201 | 358502060012930 | 218A02 | 09.81 |
| EUT D (Code: DE1015014ae02) | UMTS/LTE Module | TOBY-L201 | 358502060012930 | 218A02 | 09.82 |
| Remark: EUT A is equipped with a temporary antenna connector. The Module is not sold with a predefined antenna. | | | | | |

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

## 2.3 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.

| Short Description | Equipment under Test | Type Designation | HW Status | SW Status | Serial no. | FCC ID |
|---|---|---|---|---|---|---|
| AE 1 | AC/DC converter | UUX324-1215 | - | - | E09-0291981 | – |
| AE 2 | AC/DC converter | UUX324-1215 | - | - | E09-0291993 | – |
| AE 3 | Evaluation test board | EVB-WL3 | NO_EVK_CS_191A00 | - | - | - |
| AE 4 | Evaluation test board | EVB-WL3 | NO_EVK_CS_191A00 | - | - | - |

## 2.4 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.

| Short Description | Equipment under Test | Type Designation | Serial no. | HW Status | SW Status | FCC ID |
|---|---|---|---|---|---|---|
| * | | | | | | |

* No auxiliary equipment was required to operate the module

## 2.5 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 No. | Combination of EUTs | Description and Rationale |
|---|---|---|
| Setup_01 | EUT A + AE 1 + AE 3 | setup for conducted measurements |
| Setup_02 | EUT B + AE 1 + AE 3 | setup for conducted and radiated measurements |
| Setup_03 | EUT C + AE 2 + AE 4 | setup for conducted and radiated measurements |
| Setup_04 | EUT D + AE 2 + AE 4 | setup for conducted and radiated measurements |

## 2.6 Operating Modes

The below table shows the test frequencies and channels bandwidths used for testing.

| TEST MODE | TX / RX | RF Channel | | |
|---|---|---|---|---|
| | | Low | Mid | High |
| LTE eFDD 5 | TX (1.4M) | 20407 | 20525 | 20643 |
| | | 824.7 MHz | 836.5 MHz | 848.3 MHz |
| | TX (3M) | CH 20415 | CH 20525 | CH 20635 |
| | | 825.50 MHz | 836.50 MHz | 847.50 MHz |
| | TX (5M) | CH 20425 | CH 20525 | CH 20625 |
| | | 826.50 MHz | 836.50 MHz | 846.50 MHz |
| | TX (10) | CH 20450 | CH 20525 | CH 20600 |
| | | 829.00 MHz | 836.50 MHz | 844.00 MHz |
| | RX (1.4M) | CH 2407 | CH 20525 | CH 2643 |
| | | 869.70 MHz | 881.50 MHz | 893.70 MHz |
| | RX (3M) | CH 2415 | CH 20525 | CH 2635 |
| | | 870.50 MHz | 881.50 MHz | 892.50 MHz |
| | RX (5M) | CH 2425 | CH 2525 | CH 2625 |
| | | 871.50 MHz | 881.50 MHz | 891.50 MHz |
| | RX (10M) | CH 2450 | CH 2525 | CH 2600 |
| | | 874.00 MHz | 881.50 MHz | 889.00 MHz |

| eFDD 5 Test configuration | | | | | |
|---|---|---|---|---|---|
| **Setup Number** | **Test ITEM** | **Channel Band width** | **Channels tested** | **Modulation** | **RB Allocation** |
| 01 | RF OUTPUT POWER | 1.4 MHz | 20407, 20525, 20643 | QPSK, 16QAM | 1RB, 3RB, 6RB |
| | | 3 MHz | 20415, 20525, 20635 | QPSK, 16QAM | 1RB, 15RB |
| | | 5 MHz | 20425, 20525, 20625 | QPSK, 16QAM | 1RB , 12RB , 25RB |
| | | 10 MHz | 20450, 20525, 20635 | QPSK, 16QAM | 1RB, 50RB |
| 02 | FREQUENCY STABILITY | 1.4 MHz | 20525 | QPSK | 1RB |
| 01 | OCCUPIED BANDWIDTH | 1.4 MHz | 20407, 20525, 20643 | QPSK, 16QAM | 6RB |
| | | 3 MHz | 20415, 20525, 20635 | QPSK, 16QAM | 15RB |
| | | 5 MHz | 20425, 20525, 20625 | QPSK, 16QAM | 25RB |
| | | 10 MHz | 20450, 20525, 20635 | QPSK, 16QAM | 50RB |
| 01 | PEAK TO AVERAGE RATIO | 5 MHz | 20425, 20525, 20625 | QPSK, 16QAM | 25RB |
| 03 | BAND EDGE Compliance | 1.4 MHz | 20407, 20525, 20643 | QPSK, 16QAM | 6RB / Max offset |
| | | 3 MHz | 20415, 20525, 20635 | QPSK, 16QAM | 15RB/ Max offset |
| | | 5 MHz | 20425, 20525, 20625 | QPSK, 16QAM | 25RB/ Max offset |
| | | 10 MHz | 20450, 20525, 20635 | QPSK, 16QAM | 50RB/ Max offset |
| 02 | CONDCUDETED EMISSION | 5 MHz | 20425, 20525, 20625 | QPSK, 16QAM | 1RB |
| 02/03 | RADIATED EMISSION | 10MHz 1) | 20425, 20525, 20625 | QPSK | 1 RB mid channel / 50 RB |

1) Run of the complete frequency range, spot checks also at 1.4 MHz, 3MHz, 5 MHz.

## 2.7 Special software used for testing

NA

### 2.7.0 Software to control the EUT directly

NA

### 2.7.1 Software to enable control the EUT by a signaling unit

NA

## 2.8 Product labeling

-

### 2.8.1 FCC ID label

Please refer to the documentation of the applicant.

### 2.8.2 Location of the label on the EUT

Please refer to the documentation of the applicant.

# 3 Test Results

## 3.1 RF Power Output

**Standard FCC Part 22, Subpart H**

**The test was performed according to: FCC §2.1046**

### 3.1.1 Test Description (conducted procedure)

1) The EUT was coupled to a Spectrum Analyser and a Digital Communication Tester through a Power Divider. Refer to chapter "Setup Drawings".
2) The total insertion losses for signal path 1 and signal path 2 were measured. The values were used to correct the readings from the Spectrum Analyser and the Digital Communication Tester.
3) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.
4) Important Settings:
5) Channel (Frequency): please refer to the detailed results
6) The transmitted power of the EUT was recorded by using a spectrum analyser.

Test Description (radiated measurement procedure)

The EUT was placed inside an anechoic chamber. Refer to chapter "Setup Drawings". The EUT was coupled to a Digital Communication Tester which was located outside the chamber via a small signalling antenna.
A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.

Important Settings:
Output Power: Maximum
Channel: please refer to the detailed results
A substitution procedure is used so that the readings from the spectrum analyser are corrected and represent directly the equivalent radiated power (related to a lamda/2 dipole).
The output power was measured in both vertical and horizontal antenna polarisation during the call is established on the lowest channel, mid channel and on the highest channel. To find the worst case power all orientations (X, Y, Z) of the EUT have been measured.
The test procedure according to TIA-603-C-2004 has been considered.

### 3.1.2 Test Requirements / Limits

§2.1046 Measurements Required: RF Power Output
For transmitters other than single sideband, independent sideband and controlled carrier radiotelephone, power output shall be measured at the RF output terminals when the transmitter is adjusted in accordance with the tune-up procedure to give the values of current and voltage on the circuit elements specified in § 2.1033(c)(8). The electrical characteristics of the output terminals when this test is made shall be stated.

§22.913 Effective radiated power limits
(a)(2) Maximum ERP. … The ERP of mobile transmitters and auxiliary test transmitters must not exceed 7 Watts.

### 3.1.3 Test Protocol

| Test Band | Band-width (MHz) | Channel | Modulation | RB | RMS Conducted Power (dBm) | FCC EIRP Limit (W) | IC EIRP Limit (W) | Maximum Antenna Gain (dBi) | Verdict |
|---|---|---|---|---|---|---|---|---|---|
| eFDD5 | 1.4 | 20407 | QPSK | RB 1 | 22.90 | 11.48 | 11.5 | 17.70 | Passed |
| | | | | RB 3 | 22.83 | 11.48 | 11.5 | 17.77 | Passed |
| | | | | RB 6 | 21.90 | 11.48 | 11.5 | 18.70 | Passed |
| | | | 16QAM | RB 1 | 21.89 | 11.48 | 11.5 | 18.71 | Passed |
| | | | | RB 6 | 20.85 | 11.48 | 11.5 | 19.75 | Passed |
| | | 20525 | QPSK | RB 1 | 22.78 | 11.48 | 11.5 | 17.82 | Passed |
| | | | | RB 3 | 22.72 | 11.48 | 11.5 | 17.88 | Passed |
| | | | | RB 6 | 21.73 | 11.48 | 11.5 | 18.87 | Passed |
| | | | 16QAM | RB 1 | 21.73 | 11.48 | 11.5 | 18.87 | Passed |
| | | | | RB 6 | 20.72 | 11.48 | 11.5 | 19.88 | Passed |
| | | 20643 | QPSK | RB 1 | 22.40 | 11.48 | 11.5 | 18.20 | Passed |
| | | | | RB 3 | 22.37 | 11.48 | 11.5 | 18.23 | Passed |
| | | | | RB 6 | 21.43 | 11.48 | 11.5 | 19.17 | Passed |
| | | | 16QAM | RB 1 | 21.53 | 11.48 | 11.5 | 19.07 | Passed |
| | | | | RB 6 | 20.39 | 11.48 | 11.5 | 20.21 | Passed |
| | 3 | 20415 | QPSK | RB 1 | 22.99 | 11.48 | 11.5 | 17.61 | Passed |
| | | | | RB 15 | 21.92 | 11.48 | 11.5 | 18.68 | Passed |
| | | | 16QAM | RB 1 | 21.97 | 11.48 | 11.5 | 18.63 | Passed |
| | | | | RB 15 | 20.89 | 11.48 | 11.5 | 19.71 | Passed |
| | | 20525 | QPSK | RB 1 | 22.76 | 11.48 | 11.5 | 17.84 | Passed |
| | | | | RB 15 | 21.59 | 11.48 | 11.5 | 19.01 | Passed |
| | | | 16QAM | RB 1 | 21.79 | 11.48 | 11.5 | 18.81 | Passed |
| | | | | RB 15 | 20.66 | 11.48 | 11.5 | 19.94 | Passed |
| | | 20635 | QPSK | RB 1 | 22.39 | 11.48 | 11.5 | 18.21 | Passed |
| | | | | RB 15 | 21.44 | 11.48 | 11.5 | 19.16 | Passed |
| | | | 16QAM | RB 1 | 21.47 | 11.48 | 11.5 | 19.13 | Passed |
| | | | | RB 15 | 20.39 | 11.48 | 11.5 | 20.21 | Passed |

| Test Band | Band-width (MHz) | Channel | Modulation | RB | RMS Conducted Power (dBm) | FCC EIRP Limit (W) | IC EIRP Limit (W) | Maximum Antenna Gain (dBi) | Verdict |
|---|---|---|---|---|---|---|---|---|---|
| eFDD5 | 5 | 20425 | QPSK | RB 1 | 22.86 | 11.48 | 11.5 | 17.74 | Passed |
| | | | | RB 12 | 21.91 | 11.48 | 11.5 | 18.69 | Passed |
| | | | | RB 25 | 21.78 | 11.48 | 11.5 | 18.82 | Passed |
| | | | 16QAM | RB 1 | 21.93 | 11.48 | 11.5 | 18.67 | Passed |
| | | | | RB 25 | 20.79 | 11.48 | 11.5 | 19.81 | Passed |
| | | 20525 | QPSK | RB 1 | 22.55 | 11.48 | 11.5 | 18.05 | Passed |
| | | | | RB 12 | 21.66 | 11.48 | 11.5 | 18.94 | Passed |
| | | | | RB 25 | 21.71 | 11.48 | 11.5 | 18.89 | Passed |
| | | | 16QAM | RB 1 | 21.78 | 11.48 | 11.5 | 18.82 | Passed |
| | | | | RB 25 | 20.67 | 11.48 | 11.5 | 19.93 | Passed |
| | | 20625 | QPSK | RB 1 | 22.53 | 11.48 | 11.5 | 18.07 | Passed |
| | | | | RB 12 | 21.63 | 11.48 | 11.5 | 18.97 | Passed |
| | | | | RB 25 | 21.57 | 11.48 | 11.5 | 19.03 | Passed |
| | | | 16QAM | RB 1 | 21.41 | 11.48 | 11.5 | 19.19 | Passed |
| | | | | RB 25 | 20.45 | 11.48 | 11.5 | 20.15 | Passed |
| | 10 | 20450 | QPSK | RB 1 | 22.61 | 11.48 | 11.5 | 17.99 | Passed |
| | | | | RB 50 | 21.75 | 11.48 | 11.5 | 18.85 | Passed |
| | | | 16QAM | RB 1 | 21.65 | 11.48 | 11.5 | 18.95 | Passed |
| | | | | RB 50 | 20.72 | 11.48 | 11.5 | 19.88 | Passed |
| | | 20525 | QPSK | RB 1 | 22.92 | 11.48 | 11.5 | 17.68 | Passed |
| | | | | RB 50 | 21.70 | 11.48 | 11.5 | 18.90 | Passed |
| | | | 16QAM | RB 1 | 21.81 | 11.48 | 11.5 | 18.79 | Passed |
| | | | | RB 50 | 20.64 | 11.48 | 11.5 | 19.96 | Passed |
| | | 20600 | QPSK | RB 1 | 22.61 | 11.48 | 11.5 | 17.99 | Passed |
| | | | | RB 50 | 21.55 | 11.48 | 11.5 | 19.05 | Passed |
| | | | 16QAM | RB 1 | 21.68 | 11.48 | 11.5 | 18.92 | Passed |
| | | | | RB 50 | 20.50 | 11.48 | 11.5 | 20.10 | Passed |

## 3.2 Frequency stability

**Standard** FCC Part 22, Subpart H

**The test was performed according to: FCC §2.1055**

### 3.2.1 Test Description

1) The EUT was placed inside a temperature chamber.
2) The EUT was coupled to a Digital Communication Tester. Refer to chapter "Setup Drawings".
3) The climatic chamber was cycled down/up to a certain temperature, starting with the EUT minimum temperature.
4) After the temperature was stabilized the EUT was switched on and a call was established on a Traffic Channel between the EUT and the Digital Communication Tester.
Important Settings:
- Output Power: Maximum
- Mid Channel
5) The frequency error of the EUT was recorded by using an internal measurement function of the Digital Communication Tester immediately after the call was established, five minutes after the call was established and ten minutes after the call was established.
6) This measurement procedure was performed for temperature variation from –30°C to +50°C in increments of 10°C, if not otherwise stated in the detailed results.
When the EUT did not operate at certain temperature levels, these measurements were left out.

### 3.2.2 Test Requirements / Limits

§2.1055 Measurements required: Frequency stability

(a) The frequency stability shall be measured with variation of ambient temperature as follows:

(1) From -30° to +50° centigrade for all equipment except that specified in paragraphs (a) (2) and (3) of this section.

(b) Frequency measurements shall be made at the extremes of the specified temperature range and at intervals of not more than 10° centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stabilizing circuitry need be subjected to the temperature variation test.

(d) The frequency stability shall be measured with variation of primary supply voltage as follows:

(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

(2) For hand carried, battery powered equipment, reduce primary supply voltage to the

battery operating end point which shall be specified by the manufacturer.

(3) The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

§22.355 Frequency tolerance
…the carrier frequency of each transmitter in the Public Mobile Service must be maintained within the tolerances given in table C-1 of this section.

Table C-1.- Frequency Tolerance for Transmitters in the Public Mobile Services

| Frequency range (MHz) | Base, fixed (ppm) | Mobile up to 3 watts (ppm) | Mobile above 3 watts (ppm) |
|---|---|---|---|
| 25 to 50 | 20.0 | 20.0 | 50.0 |
| 50 to 450 | 5.0 | 5.0 | 50.0 |
| 450 to 512 | 2.5 | 5.0 | 5.0 |
| 821 to 896 | 1.5 | 2.5 | 2.5 |
| 928 to 929 | 5.0 | n/a | n/a |
| 929 to 960 | 1.5 | n/a | n/a |
| 2110 to 2220 | 10.0 | n/a | n/a |

### 3.2.3 Test Protocol

Channel: 20525 / 1.4MHz Bandwidth / 1 Resource Block / QPSK Modulation

| Temp. °C | Duration min | Voltage | Limit Hz | Freq. error Average (Hz) | Freq. error Max. (Hz) | Verdict |
|---|---|---|---|---|---|---|
| -30 | 0 | normal | 2091.25 | -5.34 | -22.6 | passed |
| -30 | 5 | | | -7.22 | -23.49 | passed |
| -30 | 10 | | | -4.63 | -23.33 | passed |
| -20 | 0 | normal | 2091.25 | -0.86 | -9.96 | passed |
| -20 | 5 | | | -1.92 | -16.35 | passed |
| -20 | 10 | | | -1.22 | -15.72 | passed |
| -10 | 0 | normal | 2091.25 | -0.3 | 10.56 | passed |
| -10 | 5 | | | -1.79 | -13.32 | passed |
| -10 | 10 | | | -0.17 | -13.33 | passed |
| 0 | 0 | normal | 2091.25 | -2.43 | -13.95 | passed |
| 0 | 5 | | | -0.72 | -13.23 | passed |
| 0 | 10 | | | -1.8 | 21.54 | passed |
| 10 | 0 | normal | 2091.25 | -7.34 | -25.66 | passed |
| 10 | 5 | | | -4.55 | -17.47 | passed |
| 10 | 10 | | | -1.56 | -20 | passed |
| 20 | 0 | low | 2091.25 | -1.46 | -11.27 | passed |
| 20 | 5 | | | -2.09 | -15.32 | passed |
| 20 | 10 | | | -2.16 | -15.72 | passed |
| 20 | 0 | normal | 2091.25 | -2.65 | -13.92 | passed |
| 20 | 5 | | | -2.35 | -15.75 | passed |
| 20 | 10 | | | -1.85 | -9.2 | passed |
| 20 | 0 | high | 2091.25 | -1.65 | -12.13 | passed |
| 20 | 5 | | | -1.67 | -9.84 | passed |
| 20 | 10 | | | -2.36 | -9.47 | passed |
| 30 | 0 | normal | 2091.25 | -1.56 | -12.92 | passed |
| 30 | 5 | | | -2.26 | -12.2 | passed |
| 30 | 10 | | | -1.54 | -15.34 | passed |
| 40 | 0 | normal | 2091.25 | -1.93 | -13.6 | passed |
| 40 | 5 | | | -1.07 | -12.8 | passed |
| 40 | 10 | | | -2.12 | -16.99 | passed |
| 50 | 0 | normal | 2091.25 | -2.63 | -11.07 | passed |
| 50 | 5 | | | -2.36 | -15.19 | passed |
| 50 | 10 | | | -2.65 | -13.02 | passed |

## 3.3 Spurious emissions at antenna terminals

Standard FCC Part 22, Subpart H

**The test was performed according to FCC §2.1051**

### 3.3.1 Test Description

1) The EUT was coupled to a Spectrum Analyser and a Digital Communication Tester through a Power Divider. Refer to chapter "Setup Drawings".
2) The total insertion losses for signal path 1 and signal path 2 were measured. The values were used to correct the readings from the Spectrum Analyser and the Digital Communication Tester.
3) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.
Important Settings:
- Output Power: Maximum
- Channel: please refer to the detailed results
4) Important Analyser Settings
- [Resolution Bandwidth]:
a) [>=1% of wanted signal bandwidth] in the Span of 1 MHz directly below and above the PCS-Band,
b) otherwise [100 kHz] (or [1 MHz] for accelerated sweep times)
c) [reduced resolution bandwidth] in case the curve of the analyser IF-Filter or the wanted EUT signal leads to an exceeding of the limit, in this case a correction factor was used
- Sweep Time: depending on the transmitting signal, the span and the resolution bandwidth
5) The spurious emissions peaks were measured in the frequency range from 9 kHz to 10 GHz (up to the 10th harmonic) during the call was established

### 3.3.2 Test Requirements / Limits

§ 2.1051 Spurious emissions at antenna terminals

The radio frequency voltage or power generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in Sec. 2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

§ 2.1057 Frequency spectrum to be investigated.

(a) In all of the measurements set forth in Secs. 2.1051 and 2.1053, the spectrum shall be investigated from the lowest radio frequency signal generated in the equipment, without going below 9 kHz, up to at least the frequency shown below:
(1) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.
(b) Particular attention should be paid to harmonics and subharmonics of the carrier frequency as well as to those frequencies removed from the carrier by multiples of the oscillator frequency. Radiation at the frequencies of multiplier stages should also be checked.
(c) The amplitude of spurious emissions which are attenuated more than 20 dB below the

permissible value need not be reported.
(d) Unless otherwise specified, measurements above 40 GHz shall be performed using a minimum resolution bandwidth of 1 MHz.

§ 22.917 Emission limitations for cellular equipment

(a) The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB.
Remark of the test laboratory: This is calculated to be -13 dBm.
(b) Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kHz or greater. In the 1 MHz bands immediately outside and adjacent to the frequency block a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. A narrower resolution bandwidth is permitted in all cases to improve measurement accuracy provided the measured power is integrated over the full required measurement bandwidth (i.e. 100 kHz or 1 percent of emission bandwidth, as specified). The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.
(c) Licensees in this service may establish an alternative out of band emission limit to be used at specified band edge(s) in specified geographical areas [...].
(d) If any emission from a transmitter operating in this service results in interference to users of another radio service, the FCC may require a greater attenuation of that emission than specified in this section.

For reporting only spurious emission levels reaching to the 20 dB margin to limit were noted.

### 3.3.3 Test Protocol

| Band / Bandwidth, Ressource Blocks | Modulation (MHz) | Channel | Detector | Resolution Bandwidth /kHz | Frequency /MHz | Peak Value /dBm | Margin to Limit /dB | Limit /dBm | Verdict |
|---|---|---|---|---|---|---|---|---|---|
| eFDD5 / 5MHz, 1RB | QPSK | 20425 | rms | 50 | 824.000 | -25.8 | 12.8 | -13 | Passed |
| | | 20525 | rms | - | - | - | - | -13 | Passed |
| | | 20625 | rms | 50 | 849.010 | -25.7 | 12.7 | -13 | Passed |
| | 16QAM | 20425 | rms | 50 | 824.000 | -26.4 | 13.4 | -13 | Passed |
| | | 20525 | rms | - | - | - | - | -13 | Passed |
| | | 20625 | rms | 50 | 849.010 | -27 | 14 | -13 | Passed |

no further values have been found with a margin of less than 20 dB

## 3.4 Emission and Occupied Bandwidth

**Standard** FCC Part 22, Subpart H

**The test was performed according to:** FCC §2.1049

### 3.4.1 Test Description

1) The EUT was coupled to a Spectrum Analyser and a Digital Communication Tester through a Power Divider. Refer to chapter "Setup Drawings".
2) The total insertion losses for signal path 1 and signal path 2 were measured. The values were used to correct the readings from the Spectrum Analyser and the Digital Communication Tester.
3) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.
Important Settings:
- Output Power: Maximum
- Channel: please refer to the detailed results
4) Important Analyser Settings:
- Resolution Bandwidth: >1% of the manufacturer's stated occupied bandwidth
5) The maximum spectral level of the modulated signal was recorded as the reference.
6) The emission bandwidth is measured as follows:
the two furthest frequencies above and below the frequency of the maximum reference level where the spectrum is –26 dB down have to be found.
7) The occupied bandwidth (99% Bandwidth) is measured as follows:
the occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5 percent of the total mean power.

The maximum number of resource blocks are used for each channel bandwidth.

### 3.4.2 Test Requirements / Limits

§ 2.1049 Measurements required: Occupied bandwidth

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured under the following conditions (as applicable):

(h) Transmitters employing digital modulation techniques - when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment will be operated. The signal shall be applied through any filter networks, pseudo-random generators or other devices required in normal service. Additionally, the occupied bandwidth shall be shown for operation with any devices used for modifying the spectrum when such devices are optional at the discretion of the user.

### 3.4.3 Test Protocol

The maximum number of resource blocks are used for each channel bandwidth.

| LTE Band 5 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Channel BW: 1.4 MHz | | | | Channel BW: 3 MHz | | | |
| | | 99% BW (MHz) | | | | 99% BW (MHz) | |
| Channel | Frequency (MHz) | QPSK | 16QAM | Channel | Frequency (MHz) | QPSK | 16QAM |
| 20407 | 824.7 | 1.2 | 1.2 | 20415 | 825.5 | 2.9 | 2.9 |
| 20525 | 836.5 | 1.2 | 1.2 | 20525 | 836.5 | 2.9 | 2.9 |
| 20643 | 848.3 | 1.2 | 1.2 | 20635 | 847.5 | 2.9 | 2.9 |

| LTE Band 5 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Channel BW: 5MHz | | | | Channel BW: 10 MHz | | | |
| | | 99% BW (MHz) | | | | 99% BW (MHz) | |
| Channel | Frequency (MHz) | QPSK | 16QAM | Channel | Frequency (MHz) | QPSK | 16QAM |
| 20425 | 826.5 | 4.6 | 4.6 | 20450 | 829 | 9.1 | 9.1 |
| 20525 | 836.5 | 4.6 | 4.6 | 20525 | 836.5 | 9.1 | 9.1 |
| 20625 | 846.5 | 4.6 | 4.6 | 20600 | 844 | 9.1 | 9.1 |

## 3.5 Band edge compliance

**Standard** FCC Part 22, Subpart H

**The test was performed according to:** FCC §22.913

### 3.5.1 Test Description

1) The EUT was coupled to a Spectrum Analyser and a Digital Communication Tester through a Power Divider. Refer to chapter "Setup Drawings".
2) The total insertion losses for signal path 1 and signal path 2 were measured. The values were used to correct the readings from the Spectrum Analyser and the Digital Communication Tester.
3) A call was established on a Traffic Channel between the EUT and the Digital Communication Tester.
Important Settings:
- Output Power: Maximum
- Channel: please refer to the detailed results
4) Important Analyser Settings:
- Resolution Bandwidth = Video Bandwidth: >1% of the manufacturer’s stated occupied bandwidth

### 3.5.2 Test Requirements / Limits

§ 22.917 Emission limitations for cellular equipment

Refer to chapter "Field strength of spurious radiation".

### 3.5.3 Test Protocol

| Band | Bandwidth (MHz) | Modulation | Resource Blocks / Offset | Channel | Detector | Peak Value (dBm) | Limit (dBm) | Verdict |
|---|---|---|---|---|---|---|---|---|
| eFDD5 | 1.4 | QPSK | 6 / 0 | 20407 | Average | -22.52 | -13 | Passed |
| | | | | | RMS | -20.11 | -13 | Passed |
| | | | 6 / Max | 20643 | Average | -22.28 | -13 | Passed |
| | | | | | RMS | -19.93 | -13 | Passed |
| | | 16QAM | 6 / 0 | 20407 | Average | -22.28 | -13 | Passed |
| | | | | | RMS | -20.11 | -13 | Passed |
| | | | 6 / Max | 20643 | Average | -21.71 | -13 | Passed |
| | | | | | RMS | -19.58 | -13 | Passed |
| | 3 | QPSK | 15 / 0 | 20415 | Average | -25.18 | -13 | Passed |
| | | | | | RMS | -21.6 | -13 | Passed |
| | | | 15 / Max | 20635 | Average | -25.51 | -13 | Passed |
| | | | | | RMS | -21.94 | -13 | Passed |
| | | 16QAM | 15 / 0 | 20415 | Average | -26.04 | -13 | Passed |
| | | | | | RMS | -22.28 | -13 | Passed |
| | | | 15 / Max | 20635 | Average | -26.8 | -13 | Passed |
| | | | | | RMS | -22.89 | -13 | Passed |
| eFDD5 | 5 | QPSK | 25 / 0 | 20425 | Average | -31.04 | -13 | Passed |
| | | | | | RMS | -26.8 | -13 | Passed |
| | | | 25 / Max | 20625 | Average | -29.84 | -13 | Passed |
| | | | | | RMS | -25.51 | -13 | Passed |
| | | 16QAM | 25 / 0 | 20425 | Average | -31.04 | -13 | Passed |
| | | | | | RMS | -26.6 | -13 | Passed |
| | | | 25 / Max | 20625 | Average | -31.37 | -13 | Passed |
| | | | | | RMS | -27.2 | -13 | Passed |
| | 10 | QPSK | 50 / 0 | 20450 | Average | -36.74 | -13 | Passed |
| | | | | | RMS | -32.43 | -13 | Passed |
| | | | 50 / Max | 20600 | Average | -35.06 | -13 | Passed |
| | | | | | RMS | -31.71 | -13 | Passed |
| | | 16QAM | 50 / 0 | 20450 | Average | -38.08 | -13 | Passed |
| | | | | | RMS | -34.09 | -13 | Passed |
| | | | 50 / Max | 20600 | Average | -36.14 | -13 | Passed |
| | | | | | RMS | -32.82 | -13 | Passed |

## 3.6 Power to Average Ratio

**Standard** RSS-132, §5.4

**The test was performed according to:** RSS-132, §5.4

A peak to average ratio measurement is performed at the conducted port of the EUT. The spectrum analyzers Complementary Cumulative Distribution Function (CCDF) measurement profile is used to determine the largest deviation between the average and the peak power of the EUT in a given bandwidth.
The CCDF curve shows how much time the peak waveform spends at or above a given average power level. The percent of time the signal spends at or above the level defines the probability for that particular power level.

KDB 971168 v02r01 – Section 5.7.1 was applied.

**Test Settings**
1. The signal analyzer's CCDF measurement profile is enabled
2. Frequency = carrier center frequency
3. Measurement BW > Emission bandwidth of signal
4. The signal analyser was set to collect one million samples to generate the CCDF curve
5. The measurement interval was set depending on the type of signal analysed. For continuous
signals (>98% duty cycle), the measurement interval was set to 1ms.

### 3.6.1 Test Protocol

| Band | Bandwidth / Resource Blocks | Channel | Modulation | Measured Value (dB) | Limit (IC) (dB) | Verdict |
|---|---|---|---|---|---|---|
| eFDD5 | 1.4 | 20407 | QPSK | 5.57 | 13 | Passed |
| | | 20525 | | 5.68 | 13 | Passed |
| | | 20643 | | 5.3 | 13 | Passed |
| | | 20407 | 16-QAM | 6.38 | 13 | Passed |
| | | 20525 | | 6.46 | 13 | Passed |
| | | 20643 | | 6.06 | 13 | Passed |

## 3.7 Field strength of spurious radiation

### 3.7.1 Test Description

1) The EUT was placed inside an anechoic chamber. Refer to chapter "Setup Drawings". The EUT was coupled to the R&S CMW500 Digital Communication Tester which was located outside the chamber via coaxial cable.
2) A call was established on a Traffic Channel (TCH) between the EUT and the base station simulator (R&S CMW500 Digital Communication Tester).
Important Settings:
- Discontinuous Transmission: OFF
- Modulation Signal: PSR16-1 (Pseudo Random Sequence)
- Output Power: Maximum
- Channel : Varied during measurements
3) A pre-calibration procedure is used so that the readings from the spectrum analyser are corrected and represent directly the equivalent radiated power (related to a lamda/2 dipole).
4) All spurious radiation measurements were made with spectrum analyser and the appropriate calibrated antennas for the frequency range of 30 MHz to 10 GHz (up to the 10th harmonic of the transmit frequency).
5) Important Analyser Settings
- [Resolution Bandwidth / Video Bandwidth]:
a) [100 kHz / 100 kHz] in the Span of 1 MHz directly below and above the GSM-Band,
b) [1 MHz / 1 MHz] otherwise
- Sweep Time: Calculated by using a formula given in the Product Standard "11.10-1 edition 4" for spurious emissions measurements (depending on the transmitting signal, the span and the resolution bandwidth)
6) The spurious emissions (peak) were measured in both vertical and horizontal antenna polarisation during the call is established on the lowest channel, mid channel and on the highest channel.
7) After this initial test, a final test according to TIA-603-C 2.2.12 Unwanted Emissions is performed on signals which are identified as being close to the limit. For any emissions found to be within 10 dB of the limit, a specific signal substitution measurement is performed at the frequency of the emission to determine the exact e.i.r.p. value.

### 3.7.2 Test Requirements / Limits

§ 2.1053 Measurements required: Field strength of spurious radiation.

Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph (c) of Sec. 2.1049, as appropriate. For equipment operating on frequencies below 890 MHz, an open field test is normally required, with the measuring instrument antenna located in the far-field at all test frequencies. In the event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurements will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with reference to the rated power output of the transmitter, assuming all emissions are radiated from halfwave dipole antennas.

(b) The measurements specified in paragraph (a) of this section shall be made for the following equipment:
(2) All equipment operating on frequencies higher than 25 MHz.

§ 2.1057 Frequency spectrum to be investigated.

(a) In all of the measurements set forth in Secs. 2.1051 and 2.1053, the spectrum shall be investigated from the lowest radio frequency signal generated in the equipment, without going below 9 kHz, up to at least the frequency shown below:
(1) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.
(b) Particular attention should be paid to harmonics and subharmonics of the carrier frequency as well as to those frequencies removed from the carrier by multiples of the oscillator frequency. Radiation at the frequencies of multiplier stages should also be checked.
(c) The amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.
(d) Unless otherwise specified, measurements above 40 GHz shall be performed using a minimum resolution bandwidth of 1 MHz.

§ 22.917 Emission limitations for cellular equipment

(a) The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB.
This is calculated to be -13 dBm (effective radiated power) which corresponds to 84.6 dBµV/m (field strength) in a distance of 3 m.
(b) Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kHz or greater. In the 1 MHz bands immediately outside and adjacent to the frequency block a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. A narrower resolution bandwidth is permitted in all cases to improve measurement accuracy provided the measured power is integrated over the full required measurement bandwidth (*i.e.* 100 kHz or 1 percent of emission bandwidth, as specified). The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.
(c) Licensees in this service may establish an alternative out of band emission limit to be used at specified band edge(s) in specified geographical areas [...].
(d) If any emission from a transmitter operating in this service results in interference to users of another radio service, the FCC may require a greater attenuation of that emission than specified in this section.

### 3.7.3 Test Protocol

**eFDD5 worst case of pre-measurement (3 MHz 15RB)**

| detector | resolution bandwidth /kHz | frequency /MHz | peak value /dBm | limit /dBm | margin to limit /dB | verdict |
|---|---|---|---|---|---|---|
| peak | 30 | 824 | -13.24 | -13.00 | 0.24 | passed |
| peak | 30 | 849 | -13.56 | -13.00 | 0.56 | passed |

no further values have been found with a margin of less than 20 dB

# 4 Test Equipment

The calibration, hardware and software states are shown for the testing period.

### Test Equipment Anechoic Chamber

| | |
|---|---|
| ***Lab ID:*** | **Lab 1** |
| *Manufacturer:* | Frankonia |
| *Description:* | Anechoic Chamber for radiated testing |
| *Type:* | 10.58x6.38x6.00 m³ |

| *Calibration Details* | *Last Execution* | *Next Exec.* |
|---|---|---|
| NSA (FCC) | 2014/01/09 | 2017/01/09 |

### Single Devices for Anechoic Chamber

| *Single Device Name* | *Type* | *Serial Number* | *Manufacturer* |
|---|---|---|---|
| Air compressor | none | - | Atlas Copco |
| Anechoic Chamber | 10.58 x 6.38 x 6.00 m³ | none | Frankonia |

| *Calibration Details* | *Last Execution* | *Next Exec.* |
|---|---|---|
| FCC listing 96716 3m Part15/18 | 2014/01/09 | 2017/01/08 |

| | | | |
|---|---|---|---|
| Controller Maturo | MCU | 961208 | Maturo GmbH |
| EMC camera | CE-CAM/1 | - | CE-SYS |
| EMC camera Nr.2 | CCD-400E | 0005033 | Mitsubishi |
| Filter ISDN | B84312-C110-E1 | | Siemens&Matsushita |
| Filter Universal 1A | BB4312-C30-H3 | - | Siemens&Matsushita |

### Test Equipment Auxiliary Equipment for Radiated emissions

| | |
|---|---|
| ***Lab ID:*** | **Lab 1** |
| *Description:* | Equipment for emission measurements |
| *Serial Number:* | see single devices |

### Single Devices for Auxiliary Equipment for Radiated emissions

| *Single Device Name* | *Type* | *Serial Number* | *Manufacturer* |
|---|---|---|---|
| Antenna mast | AM 4.0 | AM4.0/180/11920513 | Maturo GmbH |
| Biconical Broadband Antenna | SBA 9119 | 9119-005 | Schwarzbeck |
| Biconical dipole | VUBA 9117 | 9117-108 | Schwarzbeck |
| Broadband Amplifier 18MHz-26GHz | JS4-18002600-32-5P | 849785 | Miteq |
| Broadband Amplifier 1GHz-4GHz | AFS4-01000400-1Q-10P-4 | - | Miteq |
| Broadband Amplifier 30MHz-18GHz | JS4-00101800-35-5P | 896037 | Miteq |
| Cable "ESI to EMI Antenna" | EcoFlex10 | W18.01-2+W38.01-2 | Kabel Kusch |
| Cable "ESI to Horn Antenna" | UFB311A+UFB293C | W18.02-2+W38.02-2 | Rosenberger Micro-Coax |
| Double-ridged horn | HF 906 | 357357/001 | Rohde & Schwarz GmbH & Co. KG |

| *Calibration Details* | *Last Execution* | *Next Exec.* |
|---|---|---|
| Standard Calibration | 2012/05/18 | 2015/05/17 |

**Single Devices for Auxiliary Equipment for Radiated emissions (continued)**

| *Single Device Name* | *Type* | *Serial Number* | *Manufacturer* | |
|---|---|---|---|---|
| Double-ridged horn | HF 906 | 357357/002 | Rohde & Schwarz GmbH & Co. KG | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | Standard Calibration | | 2012/06/26 | 2015/06/25 |
| High Pass Filter | 4HC1600/12750-1.5-KK | 9942011 | Trilithic | |
| High Pass Filter | 5HC2700/12750-1.5-KK | 9942012 | Trilithic | |
| High Pass Filter | 5HC3500/12750-1.2-KK | 200035008 | Trilithic | |
| High Pass Filter | WHKX 7.0/18G-8SS | 09 | Wainwright | |
| Horn Antenna Schwarzbeck 15-26 GHz BBHA 9170 | BBHA 9170 | BBHA9170262 | | |
| Log.-per. Antenna | HL 562 Ultralog | 100609 | Rohde & Schwarz GmbH & Co. KG | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | Standard Calibration | | 2012/12/18 | 2015/12/17 |
| Log.-per. Antenna | HL 562 Ultralog | 830547/003 | Rohde & Schwarz GmbH & Co. KG | |
| Loop Antenna | HFH2-Z2 | 829324/006 | Rohde & Schwarz GmbH & Co. KG | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | DKD Calibration | | 2014/11/27 | 2017/11/27 |
| Standard Gain / Pyramidal Horn Antenna 26,5 GHz | 3160-09 | 00083069 | EMCO Elektronik GmbH | |
| Standard Gain / Pyramidal Horn Antenna 40 GHz | 3160-10 | 00086675 | EMCO Elektronik GmbH | |
| Tilt device Maturo (Rohacell) | Antrieb TD1.5-10kg | TD1.5-10kg/024/3790709 | Maturo GmbH | |

### Test Equipment Auxiliary Test Equipment

| | |
|---|---|
| ***Lab ID:*** | **Lab 1, Lab 2** |
| *Manufacturer:* | see single devices |
| *Description:* | Single Devices for various Test Equipment |
| *Type:* | various |
| *Serial Number:* | none |

### Single Devices for Auxiliary Test Equipment

| *Single Device Name* | *Type* | *Serial Number* | *Manufacturer* |
|---|---|---|---|
| AC Power Source | Chroma 6404 | 64040001304 | Chroma ATE INC. |
| Broadband Power Divider N (Aux) | 1506A / 93459 | LM390 | Weinschel Associates |
| Broadband Power Divider SMA | WA1515 | A855 | Weinschel Associates |
| Digital Multimeter 03 (Multimeter) | Fluke 177 | 86670383 | Fluke Europe B.V. |
| | *Calibration Details* | | *Last Execution* *Next Exec.* |
| | Customized calibration | | 2013/12/04 2015/12/03 |
| Fibre optic link Satellite (Aux) | FO RS232 Link | 181-018 | Pontis |
| Fibre optic link Transceiver (Aux) | FO RS232 Link | 182-018 | Pontis |
| Isolating Transformer | LTS 604 | 1888 | Thalheimer Transformatorenwerke GmbH |
| Notch Filter Ultra Stable (Aux) | WRCA800/960-6EEK | 24 | Wainwright |
| Signal Analyzer | FSV30 | 103005 | Rohde & Schwarz GmbH & Co. KG |
| | *Calibration Details* | | *Last Execution* *Next Exec.* |
| | Standard | | 2014/02/10 2016/02/09 |
| Spectrum Analyser | FSP3 | 836722/011 | Rohde & Schwarz GmbH & Co. KG |
| | *Calibration Details* | | *Last Execution* *Next Exec.* |
| | Standard | | 2012/06/13 2015/06/12 |
| Spectrum Analyser | FSU26 | 200418 | Rohde & Schwarz GmbH & Co.KG |
| | *Calibration Details* | | *Last Execution* *Next Exec.* |
| | Standard calibration | | 2014/07/29 2015/07/28 |
| Vector Signal Generator | SMIQ 03B | 832492/061 | Rohde & Schwarz GmbH & Co.KG |

### Test Equipment Digital Signalling Devices

***Lab ID:*** **Lab 1, Lab 2**
*Description:* Signalling equipment for various wireless technologies.

### Single Devices for Digital Signalling Devices

| *Single Device Name* | *Type* | *Serial Number* | *Manufacturer* | |
|---|---|---|---|---|
| Bluetooth Signalling Unit CBT | CBT | 100589 | Rohde & Schwarz GmbH & Co. KG | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | Standart calibration | | 2015/01/21 | 2018/01/19 |
| CMW500 | CMW500 | 107500 | Rohde & Schwarz GmbH & Co.KG | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | Standard calibration | | 2014/01/27 | 2016/01/26 |
| Digital Radio Communication Tester | CMD 55 | 831050/020 | Rohde & Schwarz GmbH & Co. KG | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | DKD calibration | | 2014/12/02 | 2017/12/01 |
| Universal Radio Communication Tester | CMU 200 | 102366 | Rohde & Schwarz GmbH & Co. KG | |
| | *HW/SW Status* | | *Date of Start* | *Date of End* |
| | Hardware:<br>B11, B21V14, B21-2, B41, B52V14, B52-2, B53-2, B56V14, B68 3v04, PCMCIA, U65V04<br>Software:<br>K21 4v21, K22 4v21, K23 4v21, K24 4v21, K42 4v21, K43 4v21, K53 4v21, K56 4v22, K57 4v22, K58 4v22, K59 4v22, K61 4v22, K62 4v22, K63 4v22, K64 4v22, K65 4v22, K66 4v22, K67 4v22, K68 4v22, K69 4v22<br>Firmware:<br>µP1 8v50 02.05.06<br>--- | | 2007/07/16 | |
| Universal Radio Communication Tester | CMU 200 | 837983/052 | Rohde & Schwarz GmbH & Co. KG | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | DKD calibration | | 2014/12/03 | 2017/12/02 |
| | *HW/SW Status* | | *Date of Start* | *Date of End* |
| | HW options:<br>B11, B21V14, B21-2, B41, B52V14, B52-2, B53-2, B54V14, B56V14, B68 3v04, B95, PCMCIA, U65V02<br>SW options:<br>K21 4v11, K22 4v11, K23 4v11, K24 4v11, K27 4v10, K28 4v10, K42 4v11, K43 4v11, K53 4v10, K65 4v10, K66 4v10, K68 4v10,<br>Firmware:<br>µP1 8v40 01.12.05<br>--- | | 2007/01/02 | |
| | SW:<br>K62, K69 | | 2008/11/03 | |
| Vector Signal Generator | SMU200A | 100912 | Rohde & Schwarz GmbH & Co. KG | |

## Test Equipment Emission measurement devices

| | |
|---|---|
| ***Lab ID:*** | **Lab 1** |
| *Description:* | Equipment for emission measurements |
| *Serial Number:* | see single devices |

### Single Devices for Emission measurement devices

| *Single Device Name* | *Type* | *Serial Number* | *Manufacturer* | |
|---|---|---|---|---|
| EMI Receiver / Spectrum Analyser | ESR 7 | 101424 | Rohde & Schwarz | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | Initial Factory Calibration | | 2014/11/13 | 2016/11/12 |
| Personal Computer | Dell | 30304832059 | Dell | |
| Power Meter | NRVD | 828110/016 | Rohde & Schwarz GmbH & Co.KG | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | Standard calibration | | 2014/05/13 | 2015/05/12 |
| Sensor Head A | NRV-Z1 | 827753/005 | Rohde & Schwarz GmbH & Co.KG | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | Standard calibration | | 2014/05/13 | 2015/05/12 |
| Signal Generator | SMR 20 | 846834/008 | Rohde & Schwarz GmbH & Co. KG | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | Standard Calibration | | 2014/06/24 | 2017/06/23 |
| Spectrum Analyser | FSW 43 | 103779 | Rohde & Schwarz | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | Initial Factory Calibration | | 2014/11/17 | 2016/11/16 |
| Spectrum Analyzer | ESIB 26 | 830482/004 | Rohde & Schwarz GmbH & Co. KG | |
| | *Calibration Details* | | *Last Execution* | *Next Exec.* |
| | Standard Calibration | | 2014/01/07 | 2016/01/31 |
| | *HW/SW Status* | | *Date of Start* | *Date of End* |
| | Firmware-Update 4.34.4 from 3.45 during calibration | | 2009/12/03 | |

## Test Equipment Radio Lab Test Equipment

***Lab ID:*** **Lab 2**
*Description:* Radio Lab Test Equipment

### Single Devices for Radio Lab Test Equipment

| *Single Device Name* | *Type* | *Serial Number* | *Manufacturer* |
|---|---|---|---|
| Broadband Power Divider SMA | WA1515 | A856 | Weinschel Associates |
| Coax Attenuator 10dB SMA 2W | 4T-10 | F9401 | Weinschel Associates |
| Coax Attenuator 10dB SMA 2W | 56-10 | W3702 | Weinschel Associates |
| Coax Attenuator 10dB SMA 2W | 56-10 | W3711 | Weinschel Associates |
| Coax Cable Huber&Suhner | Sucotest 2,0m | | Huber&Suhner |
| Coax Cable Rosenberger Micro Coax FA210A0010003030 SMA/SMA 1,0m | FA210A0010003030 | 54491-2 | Rosenberger Micro-Coax |
| Power Meter | NRVD | 828110/016 | Rohde & Schwarz GmbH & Co.KG |
| | *Calibration Details* | | *Last Execution* *Next Exec.* |
| | Standard calibration | | 2014/05/13 2015/05/12 |
| RF Step Attenuator RSP | RSP | 833695/001 | Rohde & Schwarz GmbH & Co.KG |
| Rubidium Frequency Standard | Datum, Model: MFS | 5489/001 | Datum-Beverly |
| | *Calibration Details* | | *Last Execution* *Next Exec.* |
| | Standard calibration | | 2014/07/03 2015/07/02 |
| Sensor Head A | NRV-Z1 | 827753/005 | Rohde & Schwarz GmbH & Co.KG |
| | *Calibration Details* | | *Last Execution* *Next Exec.* |
| | Standard calibration | | 2014/05/13 2015/05/12 |
| Signal Generator SME | SME03 | 827460/016 | Rohde & Schwarz GmbH & Co.KG |
| | *Calibration Details* | | *Last Execution* *Next Exec.* |
| | Standard calibration | | 2014/12/02 2017/12/01 |
| Signal Generator SMP | SMP02 | 836402/008 | Rohde & Schwarz GmbH & Co. KG |
| | *Calibration Details* | | *Last Execution* *Next Exec.* |
| | Standard calibration | | 2013/05/06 2016/05/05 |
| Spectrum Analyser | FSIQ26 | 840061/005 | Rohde & Schwarz GmbH & Co. KG |
| | *Calibration Details* | | *Last Execution* *Next Exec.* |
| | Calibration after reparation | | 2015/04/02 2017/04/01 |

### Test Equipment T/A Logger 13

| | |
|---|---|
| ***Lab ID:*** | **Lab 1, Lab 2** |
| *Description:* | Lufft Opus10 TPR |
| *Type:* | Opus10 TPR |
| *Serial Number:* | 13936 |

#### Single Devices for T/A Logger 13

| *Single Device Name* | *Type* | *Serial Number* | *Manufacturer* |
|---|---|---|---|
| ThermoAirpressure Datalogger 13 (Environ) | Opus10 TPR (8253.00) | 13936 | Lufft Mess- und Regeltechnik GmbH |

| *Calibration Details* | *Last Execution* | *Next Exec.* |
|---|---|---|
| Customized calibration | 2015/02/27 | 2017/02/26 |

### Test Equipment T/H Logger 03

| | |
|---|---|
| ***Lab ID:*** | **Lab 2** |
| *Description:* | Lufft Opus10 |
| *Serial Number:* | 7482 |

#### Single Devices for T/H Logger 03

| *Single Device Name* | *Type* | *Serial Number* | *Manufacturer* |
|---|---|---|---|
| ThermoHygro Datalogger 03 (Environ) | Opus10 THI (8152.00) | 7482 | Lufft Mess- und Regeltechnik GmbH |

| *Calibration Details* | *Last Execution* | *Next Exec.* |
|---|---|---|
| Customized calibration | 2015/02/27 | 2017/02/26 |

### Test Equipment T/H Logger 12

| | |
|---|---|
| ***Lab ID:*** | **Lab 1** |
| *Description:* | Lufft Opus10 |
| *Serial Number:* | 12482 |

#### Single Devices for T/H Logger 12

| *Single Device Name* | *Type* | *Serial Number* | *Manufacturer* |
|---|---|---|---|
| ThermoHygro Datalogger 12 (Environ) | Opus10 THI (8152.00) | 12482 | Lufft Mess- und Regeltechnik GmbH |

| *Calibration Details* | *Last Execution* | *Next Exec.* |
|---|---|---|
| Customized calibration | 2015/03/10 | 2017/03/09 |

### Test Equipment Temperature Chamber 05

| | |
|---|---|
| ***Lab ID:*** | **Lab 2** |
| *Manufacturer:* | see single devices |
| *Description:* | Temperature Chamber VT4002 |
| *Type:* | Vötsch |
| *Serial Number:* | see single devices |

#### Single Devices for Temperature Chamber 05

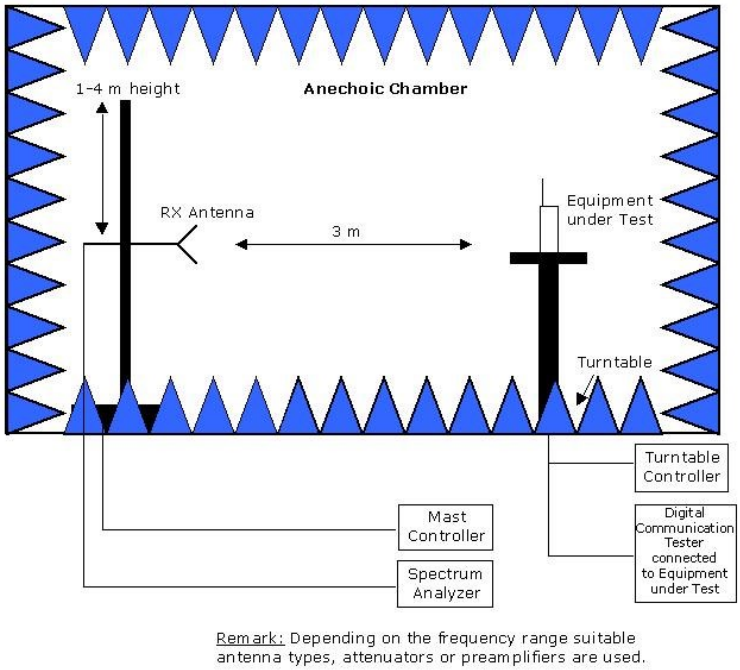
| *Single Device Name* | *Type* | *Serial Number* | *Manufacturer* |
|---|---|---|---|
| Temperature Chamber Vötsch 05 | VT 4002 | 58566080550010 | Vötsch |

| *Calibration Details* | *Last Execution* | *Next Exec.* |
|---|---|---|
| Customized calibration | 2014/03/11 | 2016/03/10 |

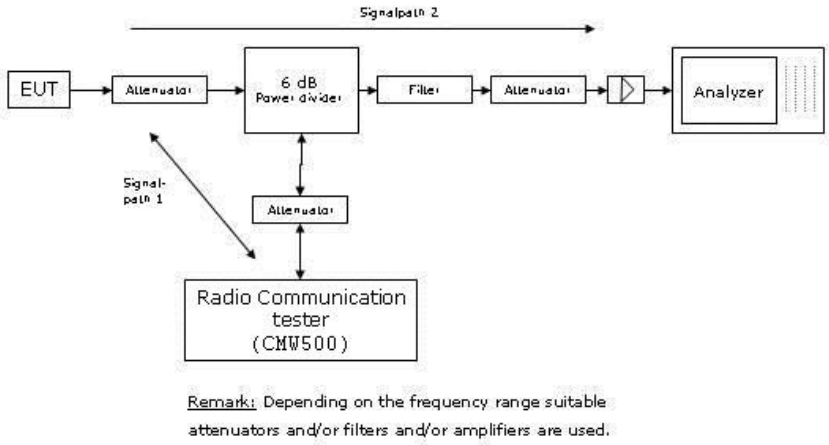
# 5 Photo Report

Photos are included in an external report.

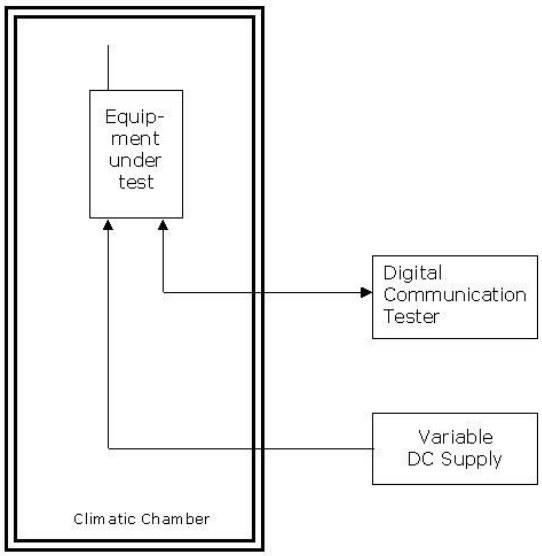
# 6 Setup Drawings




**Drawing 1:** Setup in the anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting ground plane.




Principle set-up for conducted measurements under nominal conditions

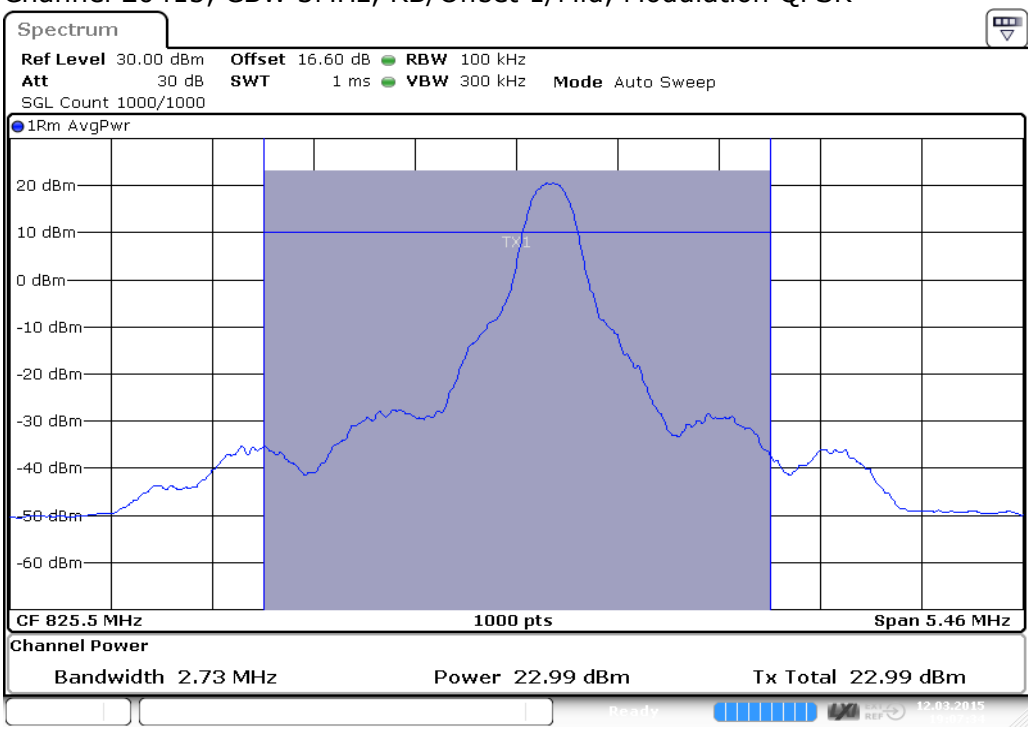



Principle set-up for tests under extreme test conditions

# 7 Annex measurement plots

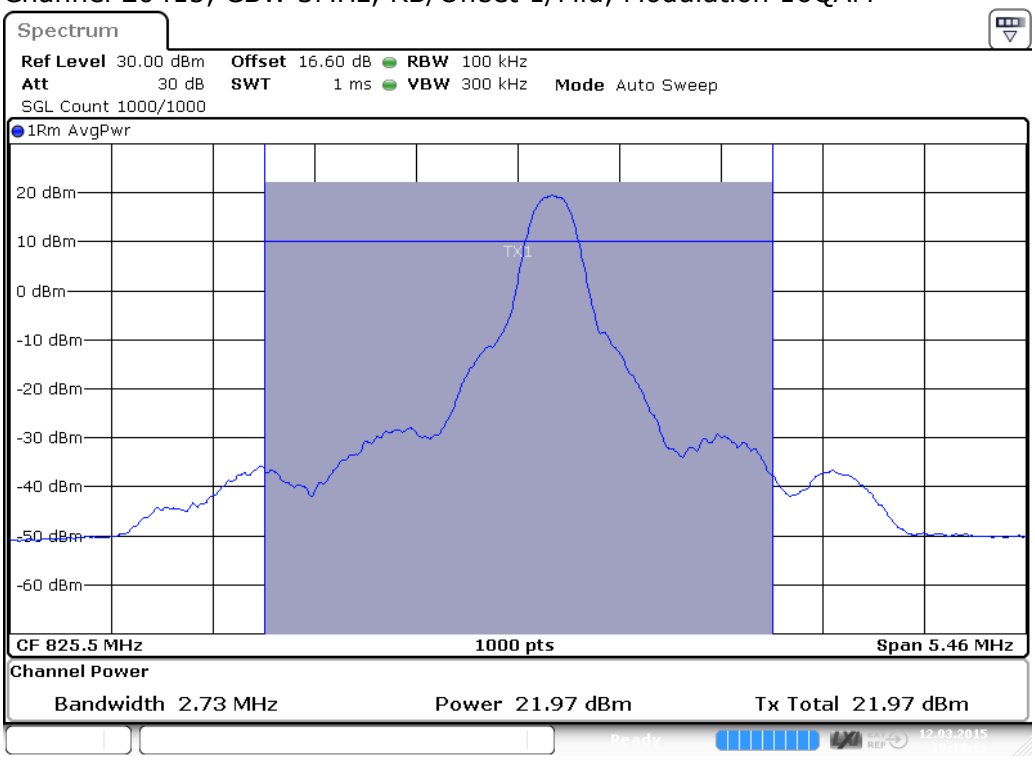
## 7.1 RF Power Output §2.1046, §22.913

Channel 20415, CBW 3MHz, RB/Offset 1/Mid, Modulation QPSK




Date: 12.MAR.2015 19:07:34

Channel 20415, CBW 3MHz, RB/Offset 1/Mid, Modulation 16QAM



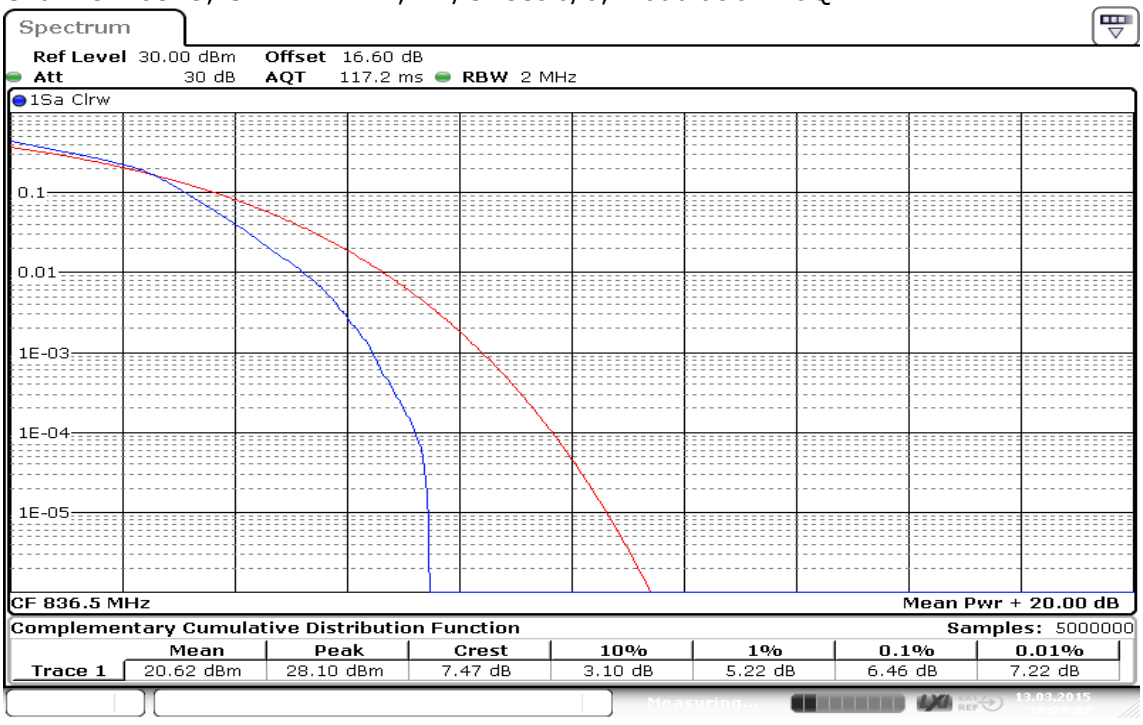

Date: 12.MAR.2015 19:10:14

## 7.2 Peak to Average Ratio RSS-132, §5.4

Channel 20525, CBW 1.4MHz, RB/Offset 6/0, Modulation QPSK


Date: 13.MAR.2015 15:20:32

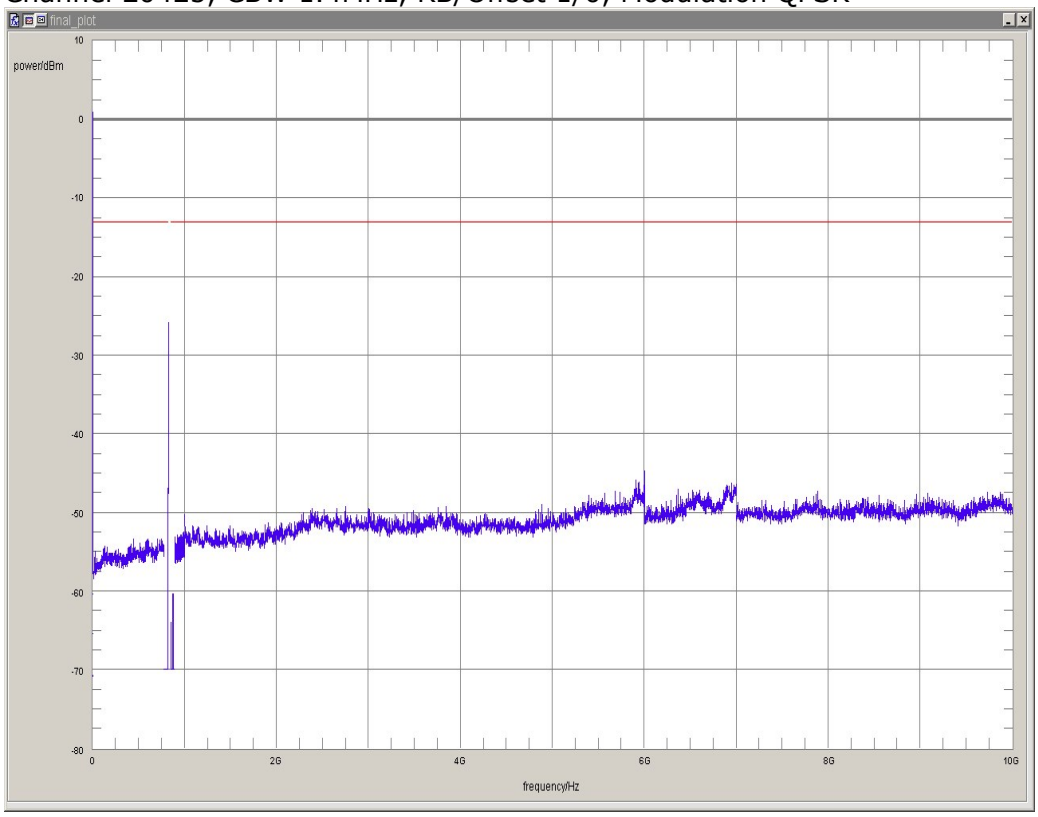
Channel 20525, CBW 1.4MHz, RB/Offset 6/0, Modulation 16QAM



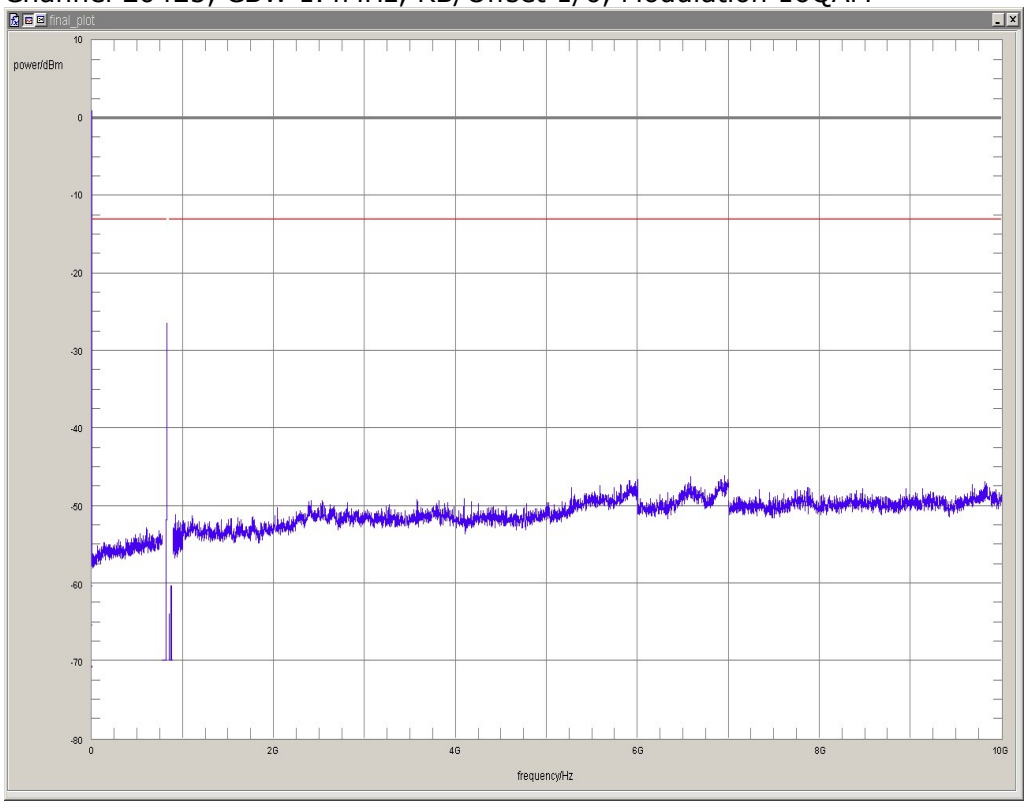

Date: 13.MAR.2015 15:20:02

## 7.3 Spurious emissions at antenna terminals §2.1051, §22.917

Channel 20425, CBW 1.4MHz, RB/Offset 1/0, Modulation QPSK

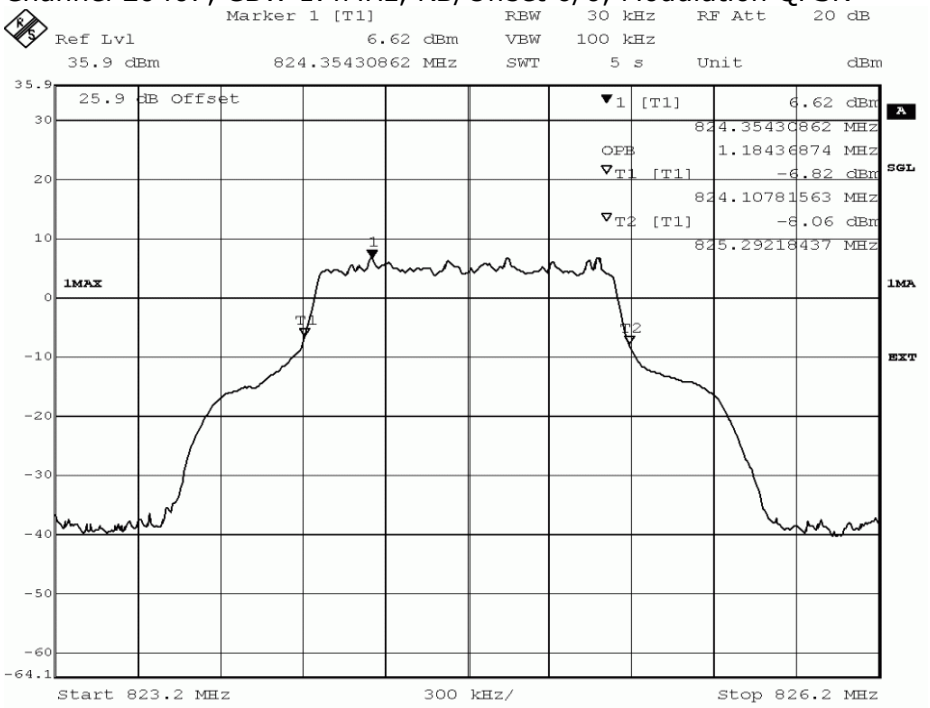



Channel 20425, CBW 1.4MHz, RB/Offset 1/0, Modulation 16QAM



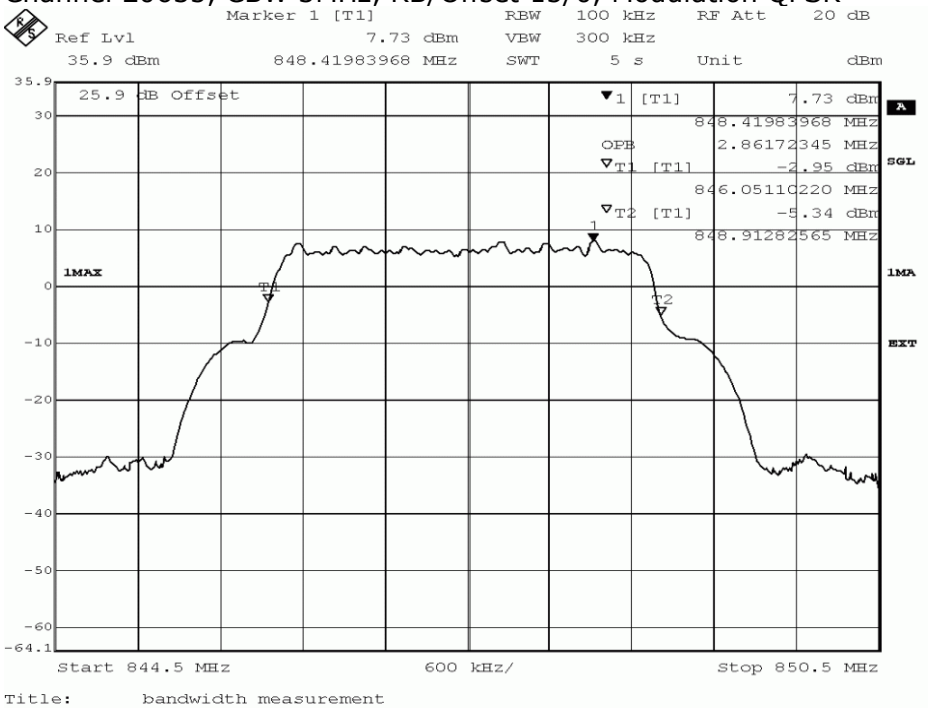
## 7.4 Emission and Occupied Bandwidth §2.1049, §22.917

Channel 20407, CBW 1.4MHz, RB/Offset 6/0, Modulation QPSK



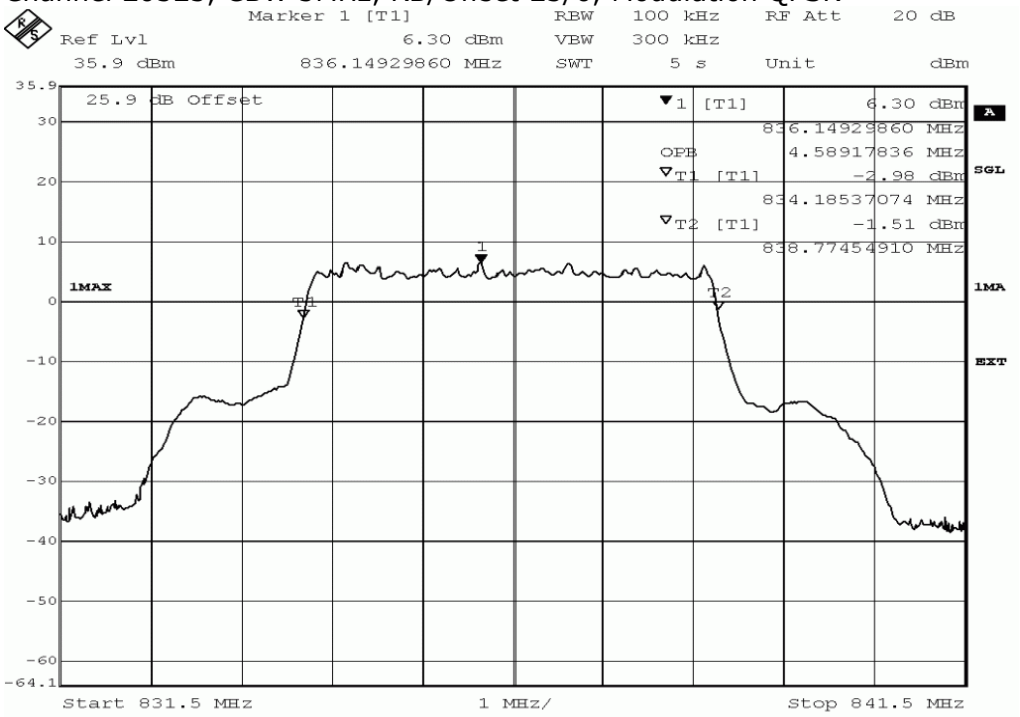

Title: bandwidth measurement
Comment A: DE1015014, eFDD5, occupied bandwidth (99%), channel 20407 (824.7MHz)
Date: 11.MAR.2015 21:22:16

Channel 20635, CBW 3MHz, RB/Offset 15/0, Modulation QPSK



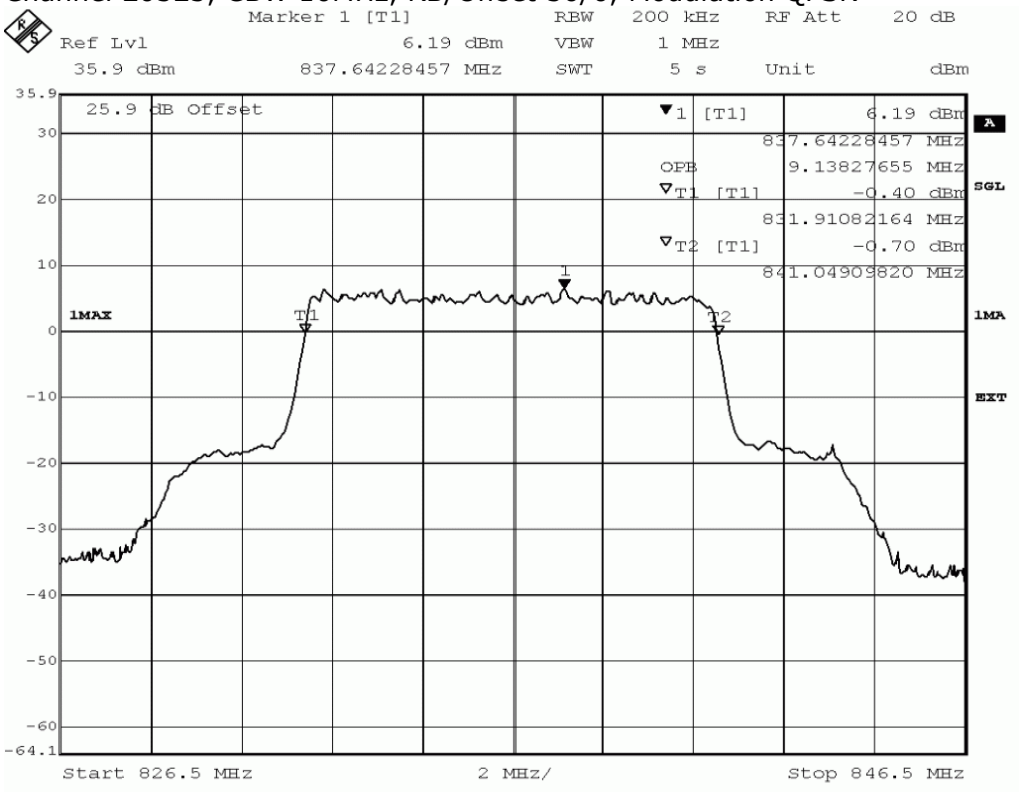

Title: bandwidth measurement
Comment A: DE1015014, eFDD5, occupied bandwidth (99%), channel 20525 (847.5MHz)
Date: 11.MAR.2015 21:59:34

Channel 20525, CBW 5MHz, RB/Offset 25/0, Modulation QPSK



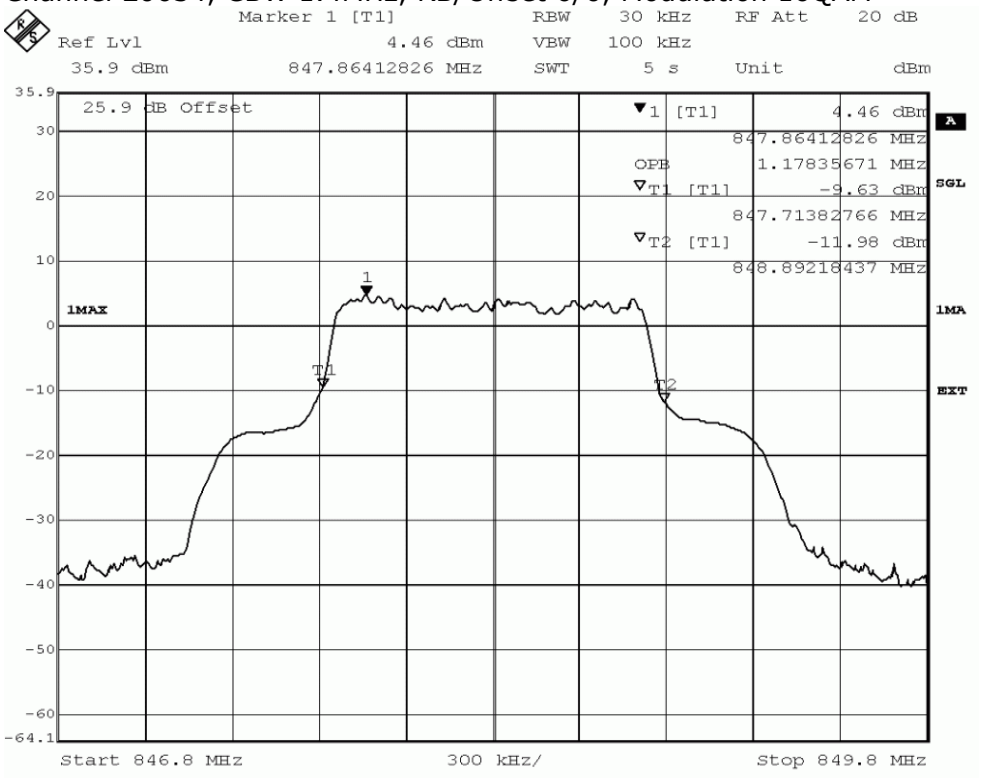

Title: bandwidth measurement
Comment A: DE1015014, eFDD5, occupied bandwidth (99%), channel 20525 (836.5MHz)
Date: 11.MAR.2015 22:13:49

Channel 20525, CBW 10MHz, RB/Offset 50/0, Modulation QPSK



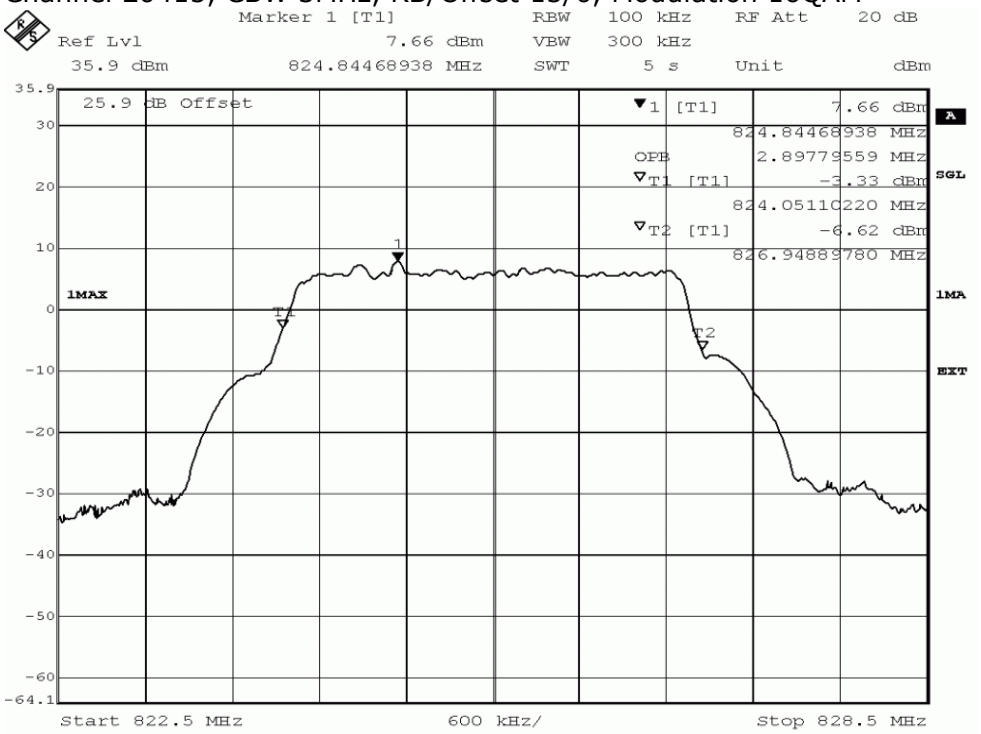

Title: bandwidth measurement
Comment A: DE1015014, eFDD5, occupied bandwidth (99%), channel 20525 (836.5MHz)
Date: 11.MAR.2015 22:25:28

Channel 20634, CBW 1.4MHz, RB/Offset 6/0, Modulation 16QAM



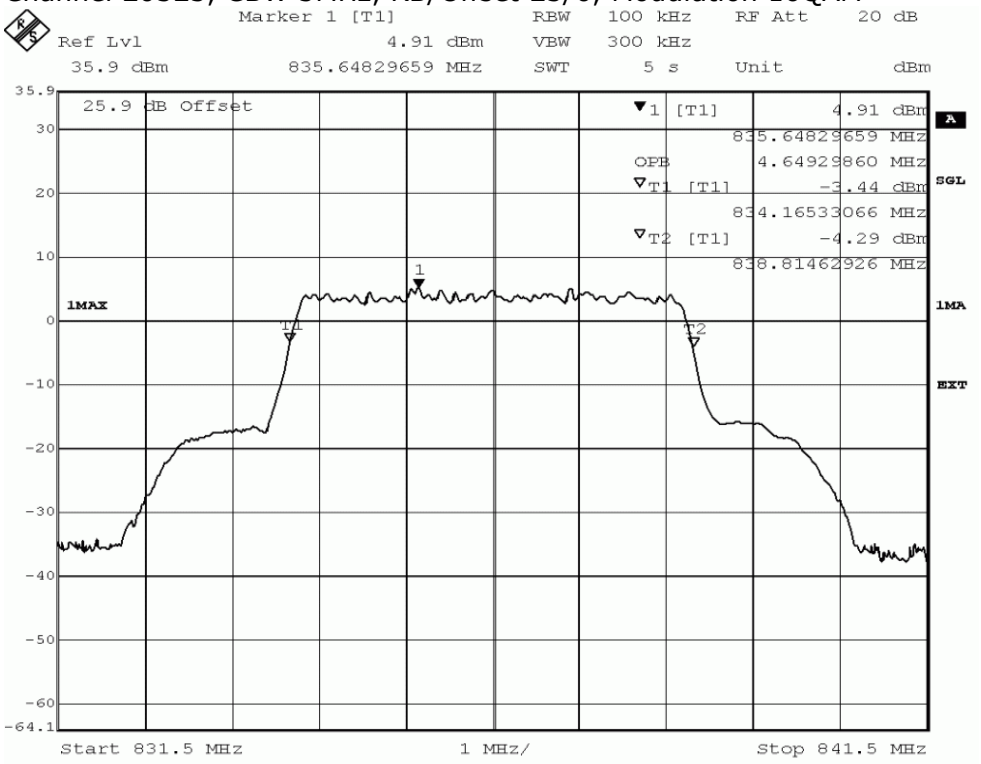

Title: bandwidth measurement
Comment A: DE10015014, eFDD5, occupied bandwidth (99%), channel 20643 (848.3MHz)
Date: 11.MAR.2015 21:33:51

Channel 20415, CBW 3MHz, RB/Offset 15/0, Modulation 16QAM



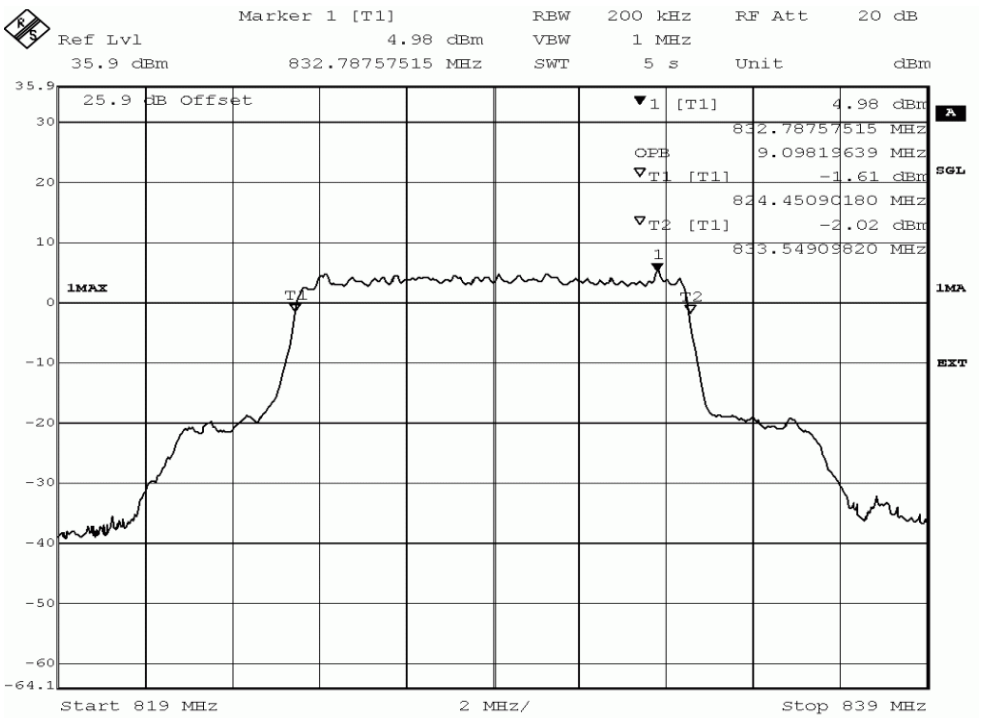

Title: bandwidth measurement
Comment A: DE10015014, eFDD5, occupied bandwidth (99%), channel 20415 (825.5MHz)
Date: 11.MAR.2015 21:43:01

Channel 20525, CBW 5MHz, RB/Offset 25/0, Modulation 16QAM




Title: bandwidth measurement
Comment A: DE1015014, eFDD5, occupied bandwidth (99%),
channel 20525 (836.5MHz)
Date: 11.MAR.2015 22:11:53

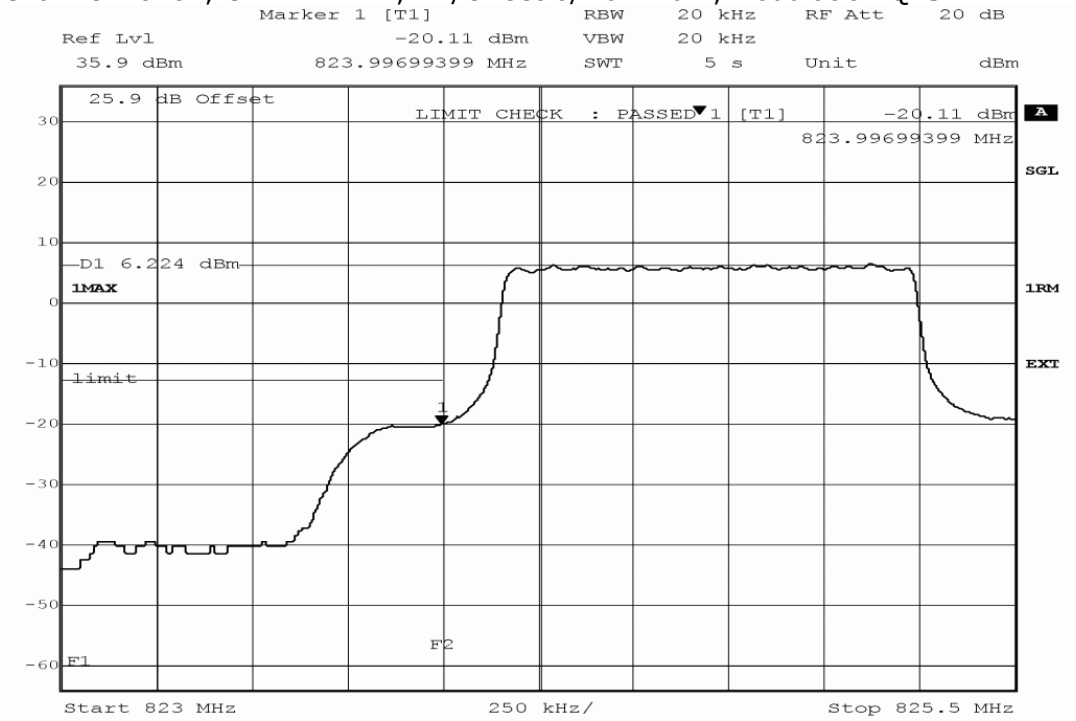
Channel 20450, CBW 10MHz, RB/Offset 50/0, Modulation 16QAM



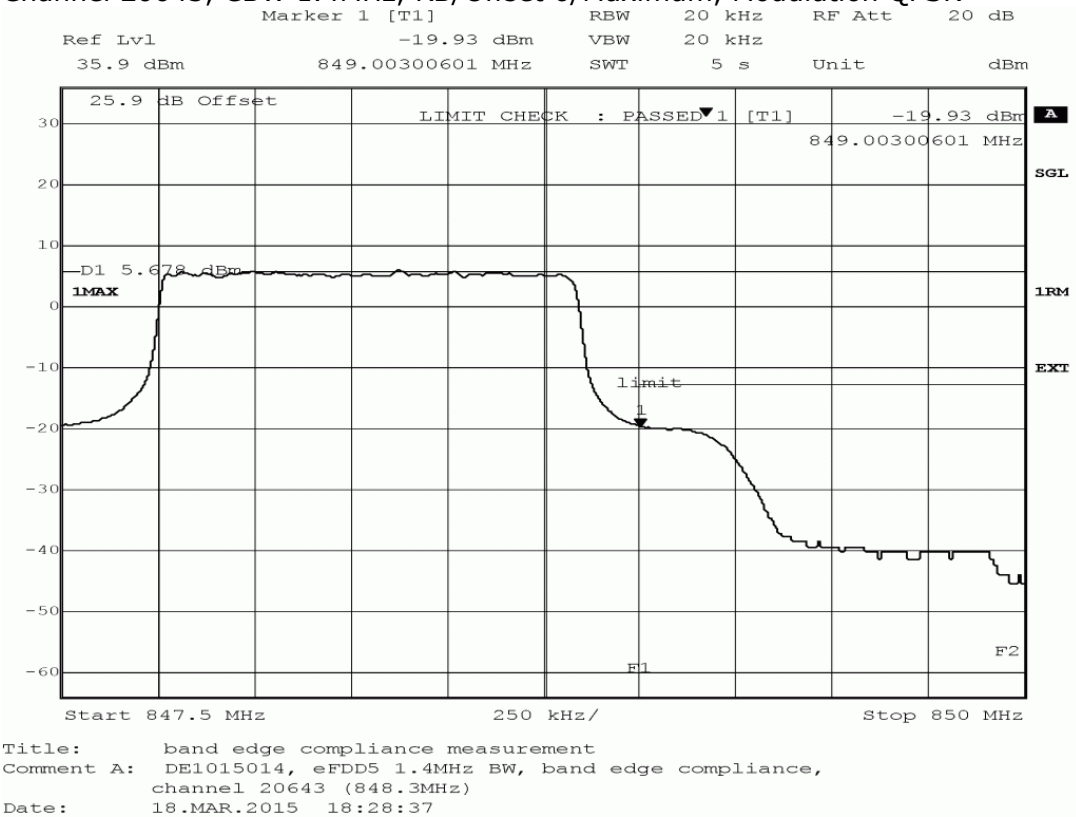

Title: bandwidth measurement
Comment A: DE1015014, eFDD5, occupied bandwidth (99%),
channel 20450 (829.0MHz)
Date: 11.MAR.2015 22:21:45

## 7.5 Band edge compliance §2.1053, §22.917

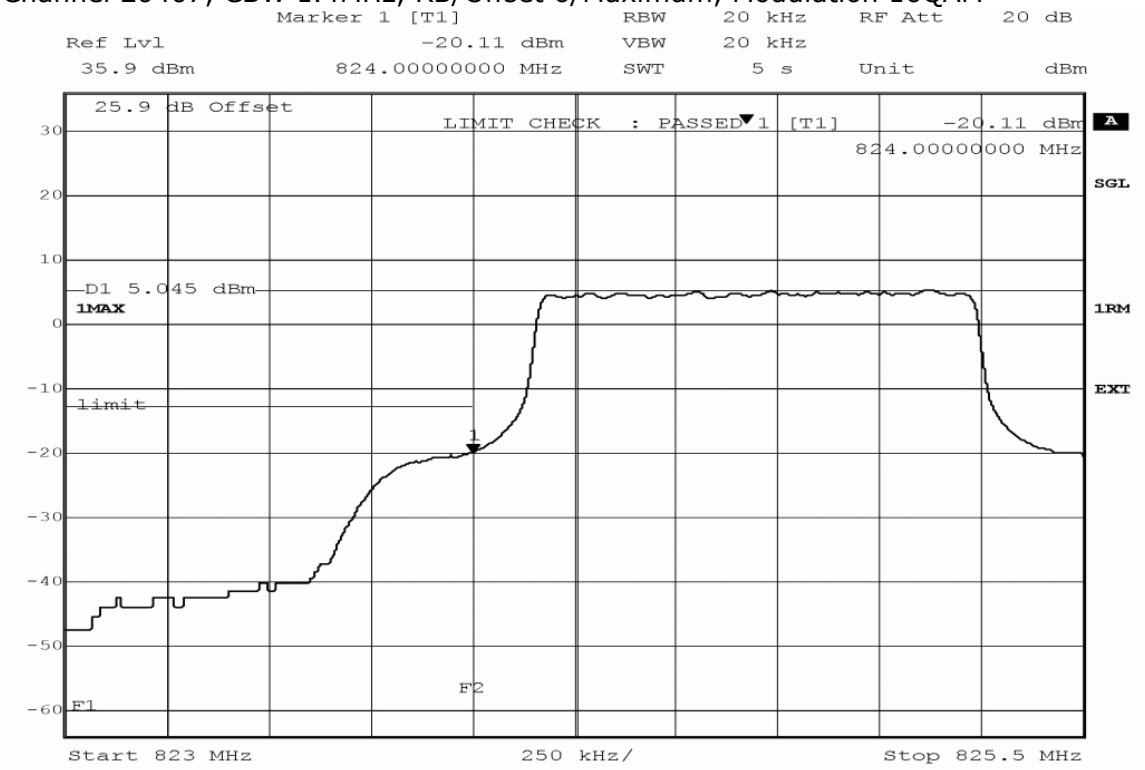
Channel 20407, CBW 1.4MHz, RB/Offset 6/Maximum, Modulation QPSK




Channel 20643, CBW 1.4MHz, RB/Offset 6/Maximum, Modulation QPSK

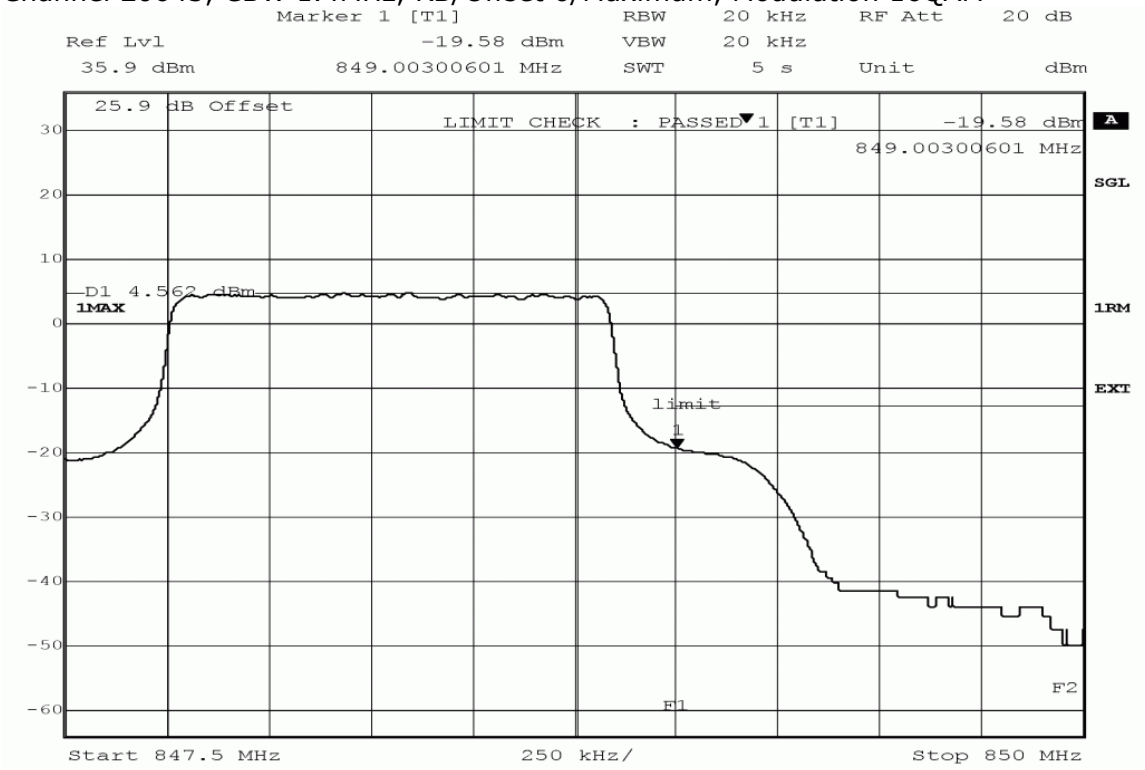


Channel 20407, CBW 1.4MHz, RB/Offset 6/Maximum, Modulation 16QAM




Title: band edge compliance measurement
Comment A: DE1015014, eFDD5 1.4MHz BW, band edge compliance, channel 20407 (824.7MHz)
Date: 18.MAR.2015 18:33:47

Channel 20643, CBW 1.4MHz, RB/Offset 6/Maximum, Modulation 16QAM




Title: band edge compliance measurement
Comment A: DE1015014, eFDD5 1.4MHz BW, band edge compliance, channel 20643 (848.3MHz)
Date: 18.MAR.2015 18:31:09

## 7.6 Field strength of spurious radiation §2.1046, §22.917

Channel 20525, CBW 10MHz, RB/Offset 1/Mid, Modulation QPSK