# FCC Measurement/Technical Report on

# SARA-R410

# FCC ID: XPY2AGQN4NNN
# IC: 8595A-2AGQN4NNN

FCC Part 24
**Test Report Reference:** MDE_UBLOX_1901_FCCc_REV01

**Test Laboratory:**
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany

Deutsche Akkreditierungsstelle
D-PL-12140-01-00

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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# 1 APPLIED STANDARDS AND TEST SUMMARY

## 1.1 APPLIED STANDARDS

**Type of Authorization**
Certification for an Industrial Signal Booster.

**Applicable FCC Rules**

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 24, (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 24, Subpart E – Broadband PCS

§ 24.232 – Power and antenna height limits
§ 24.235 – Frequency stability
§ 24.238 – Emission limitations for Broadband PCS equipment

The tests were selected and performed with reference to:

- FCC Public Notice 971168 applying "Measurement guidance for certification of licensed digital transmitters" 971168 D01 v03r01, 2018-04-09
- ANSI C63.26: 2015

**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 Cellular Mobile Devices from FCC and ISED Canada**

| Measurement | FCC reference | ISED reference |
|---|---|---|
| RF Output Power | § 2.1046<br>§ 24.232 | RSS-GEN Issue 5, 6.12<br>RSS-133 Issue 6, 6.4 |
| Peak-Average-Ratio | § 24.232 | RSS 133 Issue 6: 6.4 |
| Emission and Occupied bandwidth | § 2.1049 | RSS-GEN Issue 5, 6.7 |
| Spurious Emission at Antenna Terminals | § 2.1051<br>§ 24.238 | RSS-GEN Issue 5, 6.13<br>RSS-133 Issue 6, 6.5 |
| Band Edge Compliance | § 2.1051<br>§ 24.238 | RSS-GEN Issue 5, 6.13<br>RSS-133 Issue 6, 6.5 |
| Frequency stability | § 2.1055<br>§ 24.235 | RSS-GEN Issue 5, 6.11<br>RSS-133 Issue 6: 6.3 |
| Field strength of spurious radiation | § 2.1053<br>§ 24.236 | RSS-GEN Issue 5, 6.13<br>RSS-133 Issue 6: 6.5 |

## 1.3 MEASUREMENT SUMMARY / SIGNATURES

**47 CFR CHAPTER I FCC PART 24 Subpart E § 2.1046 § 24.232**

RF Output power
The measurement was performed according to ANSI C63.26: 2015

| **OP-Mode**<br>Technology, Radio Technology, Operating Frequency, ChBW, Ressource Blocks, Measurement method | **Setup** | **Final Result**<br>**FCC** | **IC** |
|---|---|---|---|
| CAT-M1, eFDD 2 16QAM, high channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 16QAM, high channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 16QAM, low channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 16QAM, low channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 16QAM, mid channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 16QAM, mid channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, high channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, high channel, 1.4 MHz, 3, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, high channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, low channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, low channel, 1.4 MHz, 3, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, low channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, mid channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, mid channel, 1.4 MHz, 3, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, mid channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, high channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, high channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, low channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, low channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, mid channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, mid channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, high channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, high channel, 1.4 MHz, 3, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, high channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, low channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, low channel, 1.4 MHz, 3, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, low channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, mid channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, mid channel, 1.4 MHz, 3, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, mid channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 BPSK, high channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 BPSK, low channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 BPSK, mid channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, high channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, high channel, 0.2 MHz, 12, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, high channel, 0.2 MHz, 3, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, high channel, 0.2 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, low channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, low channel, 0.2 MHz, 12, conducted | S01_AB01 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 24 Subpart E § 2.1046 § 24.232**

RF Output power

The measurement was performed according to ANSI C63.26: 2015 **Final Result**

| **OP-Mode**<br>Technology, Radio Technology, Operating Frequency, ChBW, Ressource Blocks, Measurement method | **Setup** | **FCC** | **IC** |
|---|---|---|---|
| NB-IoT, eFDD 2 QPSK, low channel, 0.2 MHz, 3, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, low channel, 0.2 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, mid channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, mid channel, 0.2 MHz, 12, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, mid channel, 0.2 MHz, 3, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, mid channel, 0.2 MHz, 6, conducted | S01_AB01 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 24 Subpart E § 2.1055 § 24.235**

Frequency stability

The measurement was performed according to ANSI C63.26: 2015 **Final Result**

| **OP-Mode**<br>Technology, Radio Technology, Operating Frequency, ChBW, Ressource Blocks, Measurement method | **Setup** | **FCC** | **IC** |
|---|---|---|---|
| CAT-M1, eFDD 2 QPSK, mid channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, mid channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, mid channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 24 Subpart E § 2.1051 § 24.238**

Spurious emissions at antenna terminal

The measurement was performed according to ANSI C63.26: 2015 **Final Result**

| **OP-Mode**<br>Technology, Radio Technology, Operating Frequency, ChBW, Ressource Blocks, Measurement method | **Setup** | **FCC** | **IC** |
|---|---|---|---|
| CAT-M1, eFDD 2 QPSK, high channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, low channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, mid channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, high channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, low channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, mid channel, 1.4 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, high channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, low channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, mid channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 24 Subpart E § 2.1053 § 24.236**

Field strength of spurious radiation

The measurement was performed according to ANSI C63.26: 2015

| **OP-Mode**<br>Technology, Radio Technology, Operating Frequency, ChBW, Ressource Blocks, Measurement method | **Setup** | **Final Result**<br>**FCC** | **IC** |
|---|---|---|---|
| CAT-M1, eFDD 2 QPSK, high channel, 1.4 MHz, 1, radiated | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, low channel, 1.4 MHz, 1, radiated | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, mid channel, 1.4 MHz, 1, radiated | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, high channel, 1.4 MHz, 1, radiated | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, low channel, 1.4 MHz, 1, radiated | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, mid channel, 1.4 MHz, 1, radiated | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, high channel, 0.2 MHz, 1, radiated | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, low channel, 0.2 MHz, 1, radiated | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, mid channel, 0.2 MHz, 1, radiated | S01_AB01 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 24 Subpart E § 2.1049**

Emission and occupied bandwidth

The measurement was performed according to ANSI C63.26: 2015

| **OP-Mode**<br>Technology, Radio Technology, Operating Frequency, ChBW, Ressource Blocks, Measurement method | **Setup** | **Final Result**<br>**FCC** | **IC** |
|---|---|---|---|
| CAT-M1, eFDD 2 16QAM, high channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 16QAM, low channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 16QAM, mid channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, high channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, low channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, mid channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, high channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, low channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, mid channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, high channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, low channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, mid channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 BPSK, high channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 BPSK, low channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 BPSK, mid channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, high channel, 0.2 MHz, 12, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, low channel, 0.2 MHz, 12, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, mid channel, 0.2 MHz, 12, conducted | S01_AB01 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 24 Subpart E § 2.1051 § 24.238**

Band edge compliance

The measurement was performed according to ANSI C63.26: 2015 **Final Result**

| **OP-Mode**<br>Technology, Radio Technology, Operating Frequency, ChBW, Ressource Blocks, Measurement method | **Setup** | **FCC** | **IC** |
|---|---|---|---|
| CAT-M1, eFDD 2 16QAM, high channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 16QAM, low channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, high channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, low channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, high channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, low channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, high channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, low channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 BPSK, high channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 BPSK, low channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, high channel, 0.2 MHz, 12, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, low channel, 0.2 MHz, 12, conducted | S01_AB01 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 24 Subpart E § 24.232**

Peak to Average Ratio

The measurement was performed according to ANSI C63.26: 2015 **Final Result**

| **OP-Mode**<br>Technology, Radio Technology, Operating Frequency, ChBW, Ressource Blocks, Measurement method | **Setup** | **FCC** | **IC** |
|---|---|---|---|
| CAT-M1, eFDD 2 16QAM, high channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 16QAM, low channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 16QAM, mid channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, high channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, low channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 2 QPSK, mid channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, high channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, low channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 16QAM, mid channel, 1.4 MHz, 5, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, high channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, low channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| CAT-M1, eFDD 25 QPSK, mid channel, 1.4 MHz, 6, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 BPSK, high channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 BPSK, low channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 BPSK, mid channel, 0.2 MHz, 1, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, high channel, 0.2 MHz, 12, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, low channel, 0.2 MHz, 12, conducted | S01_AB01 | Passed | Passed |
| NB-IoT, eFDD 2 QPSK, mid channel, 0.2 MHz, 12, conducted | S01_AB01 | Passed | Passed |

N/A: Not applicable
N/P: Not performed

## 2 REVISION HISTORY

| Report version control | | | |
|---|---|---|---|
| **Version** | **Release date** | **Change Description** | **Version validity** |
| initial | 2019-05-10 | -- | invalid |
| REV01 | 2019-05-20 | Hardware Version of the EUT changed | valid |

COMMENT: -

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

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

7 layers GmbH, Borsigstr. 11
40880 Ratingen, Germany
Phone +49 (0)2102 749 0

# 3 ADMINISTRATIVE DATA

## 3.1 TESTING LABORATORY

| | |
|---|---|
| Company Name: | 7layers GmbH |
| Address: | Borsigstr. 11<br>40880 Ratingen<br>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: | 2019-02-12 |

## 3.2 PROJECT DATA

| | |
|---|---|
| Responsible for testing and report: | B.Sc. Jens Dörwald |
| Employees who performed the tests: | documented internally at 7Layers |
| Date of Report: | 2019-05-20 |
| Testing Period: | 2019-02-13 to 2019-04-04 |

## 3.3 APPLICANT DATA

| | |
|---|---|
| Company Name: | u-blox AG |
| Address: | Zürcherstrasse 68<br>8800 Thalwil<br>Switzerland |
| Contact Person: | Mr. Giulio Comar |

## 3.4 MANUFACTURER DATA

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

# 4 TEST OBJECT DATA

## 4.1 GENERAL EUT DESCRIPTION

| | |
|---|---|
| Kind of Device product description | LTE CAT-M1 & NB-IoT module. |
| Product name | SARA-R410 |
| Type | - |
| **Declared EUT data by the supplier** | |
| General product description | The EUT is LTE CAT-M1 & NB-IoT module. It supports the relevant bands for FCC Approval<br>LTE CAT-M1: eFDD2 / LTE eFDD4 / eFDD5 / eFDD12 / eFDD13 / eFDD25 /eFDD26<br>NB-IoT: eFDD2 / LTE eFDD4 / eFDD5 / eFDD12 / eFDD13 |
| Voltage Level | 3.8 V |
| Voltage Type | DC |

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

## 4.2 EUT MAIN COMPONENTS

| **Sample Name** | **Sample Code** | **Description** |
|---|---|---|
| DE1015105 | ab01 | |
| **Sample Parameter** | **Value** | |
| Serial No. | 352753095787196 | |
| HW Version | 306B01 | |
| SW Version | L0.08.01 | |
| Comment | - | |

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

## 4.3 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 (Manufacturer, Type Model, OUT Code)** | **Description** |
|---|---|---|
| - | - | - |

## 4.4 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 (Manufacturer, Type Model, HW, SW, S/N)** | **Description** |
|---|---|---|
| - | - | - |

## 4.5 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_AB01 | DE1015105ab01 | radiated & conducted sample |

## 4.6 OPERATING MODES

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

### 4.6.1 TEST CHANNELS

| **LTE CAT-M1 eFDD 2** | **LOW** | **MID** | **HIGH** |
|---|---|---|---|
| **Channel** | 18607 | 18900 | 19193 |
| **Frequency [MHz]** | 1850.7 | 1880 | 1909.3 |

| **LTE CAT-M1 eFDD 25** | **LOW** | **MID** | **HIGH** |
|---|---|---|---|
| **Channel** | 26047 | 26365 | 26683 |
| **Frequency [MHz]** | 1850.7 | 1882.5 | 1914.3 |

| **NB-IoT eFDD 2** | **LOW** | **MID** | **HIGH** |
|---|---|---|---|
| **Channel** | 18601 | 18900 | 19199 |
| **Frequency [MHz]** | 1850.1 | 1880 | 1909.9 |

## 4.7 PRODUCT LABELLING

### 4.7.1 FCC ID LABEL

Please refer to the documentation of the applicant.

### 4.7.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

# 5 TEST RESULTS

## 5.1 RF OUTPUT POWER

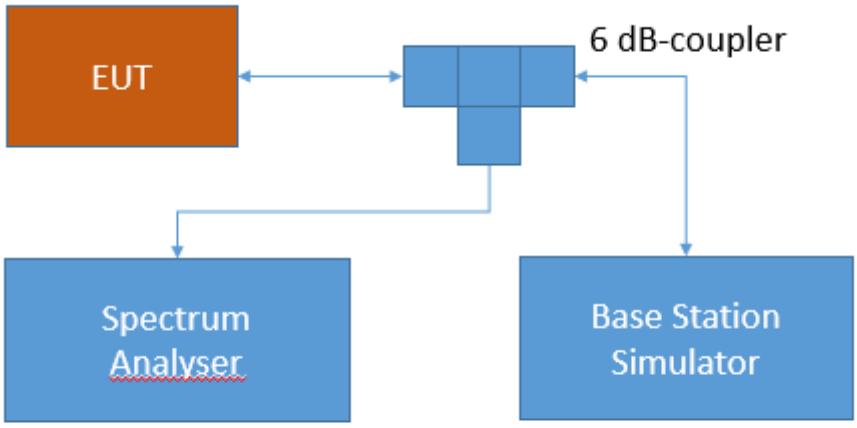
Standard **FCC PART 24 Subpart E**

**The test was performed according to:**
ANSI C63.26: 2015

### 5.1.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable RF Output power test case per § 2.1046 and RSS-GEN 6.12. The limit and the requirements come from the applicable rule part and ISED RSS-Standard for the operating band of the cellular device.

The EUT was connected to the test setup according to the following diagram:




Test Setup FCC Part 22/24/27/90 Cellular;
RF Output power

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

### 5.1.2 TEST REQUIREMENTS / LIMITS

**FCC Part 24, § 24.232**

(c) Mobile and portable stations are limited to 2 watts EIRP and the equipment must employ a means for limiting power to the minimum necessary for successful communications.

**RSS-133; 6.4 Transmitter Output Power and Equivalent Isotropically Radiated Power**

The equivalent isotropically radiated power (e.i.r.p.) for transmitters shall not exceed the limits given in SRSP-510.

**SRSP-510; 5.1.2 Radiated Power and Antenna Height Limits – Mobile Stations**

Mobile stations and hand-held portables are limited to 2 watts maximum e.i.r.p. The equipment shall employ means to limit the power to the minimum necessary for successful communication.

### 5.1.3 TEST PROTOCOL

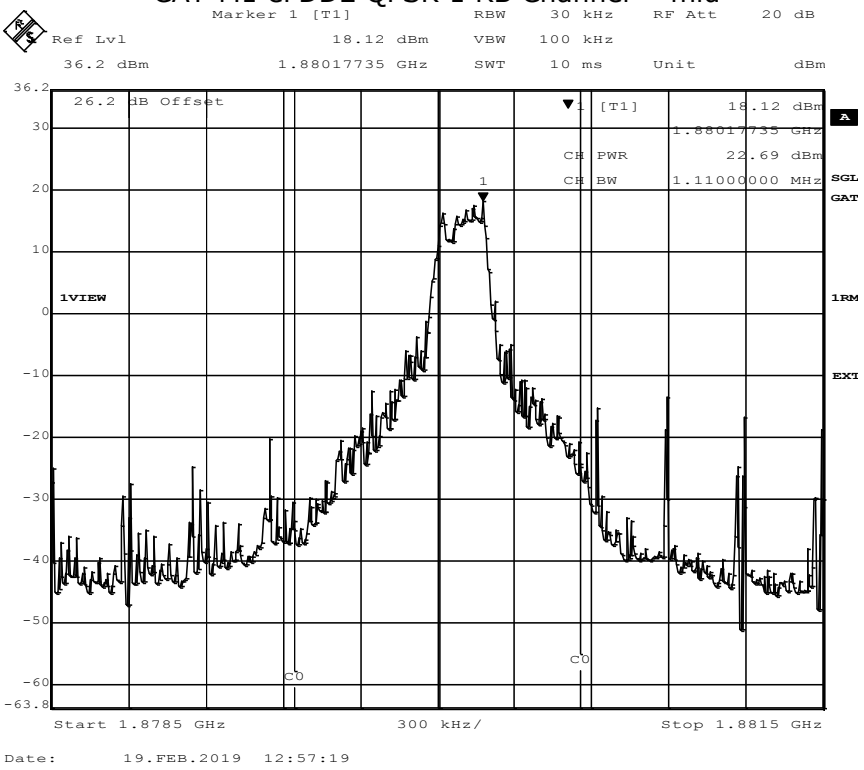
Ambient temperature 23 °C
Relative Humidity 34 %

| Radio Technology | Channel | Ressource Blocks / Subcarrier | Bandwidth [MHz] | RMS Conducted Power [dBm] | FCC EIRP Limit [W] | IC EIRP Limit [W] | Maximum Antenna Gain FCC [dBi] | Maximum Antenna Gain IC [dBi] |
|---|---|---|---|---|---|---|---|---|
| CAT-M1 eFDD 2 QPSK | low | 1 | 1.4 | 22.74 | 2 | 2 | 10.26 | 10.26 |
| CAT-M1 eFDD 2 QPSK | low | 3 | 1.4 | 21.77 | 2 | 2 | 11.23 | 11.23 |
| CAT-M1 eFDD 2 QPSK | low | 6 | 1.4 | 20.69 | 2 | 2 | 12.31 | 12.31 |
| CAT-M1 eFDD 2 QPSK | mid | 1 | 1.4 | 22.69 | 2 | 2 | 10.31 | 10.31 |
| CAT-M1 eFDD 2 QPSK | mid | 3 | 1.4 | 21.77 | 2 | 2 | 11.23 | 11.23 |
| CAT-M1 eFDD 2 QPSK | mid | 6 | 1.4 | 20.79 | 2 | 2 | 12.21 | 12.21 |
| CAT-M1 eFDD 2 QPSK | high | 1 | 1.4 | 22.64 | 2 | 2 | 10.36 | 10.36 |
| CAT-M1 eFDD 2 QPSK | high | 3 | 1.4 | 21.50 | 2 | 2 | 11.5 | 11.5 |
| CAT-M1 eFDD 2 QPSK | high | 6 | 1.4 | 20.60 | 2 | 2 | 12.4 | 12.4 |
| CAT-M1 eFDD 2 16QAM | low | 1 | 1.4 | 21.75 | 2 | 2 | 11.25 | 11.25 |
| CAT-M1 eFDD 2 16QAM | low | 5 | 1.4 | 20.37 | 2 | 2 | 12.63 | 12.63 |
| CAT-M1 eFDD 2 16QAM | mid | 1 | 1.4 | 21.58 | 2 | 2 | 11.42 | 11.42 |
| CAT-M1 eFDD 2 16QAM | mid | 5 | 1.4 | 20.46 | 2 | 2 | 12.54 | 12.54 |
| CAT-M1 eFDD 2 16QAM | high | 1 | 1.4 | 21.69 | 2 | 2 | 11.31 | 11.31 |
| CAT-M1 eFDD 2 16QAM | high | 5 | 1.4 | 20.38 | 2 | 2 | 12.62 | 12.62 |
| CAT-M1 eFDD 25 QPSK | low | 1 | 1.4 | 22.06 | 2 | 2 | 10.94 | 10.94 |
| CAT-M1 eFDD 25 QPSK | low | 3 | 1.4 | 21.16 | 2 | 2 | 11.84 | 11.84 |
| CAT-M1 eFDD 25 QPSK | low | 6 | 1.4 | 20.02 | 2 | 2 | 12.98 | 12.98 |
| CAT-M1 eFDD 25 QPSK | mid | 1 | 1.4 | 22.49 | 2 | 2 | 10.51 | 10.51 |
| CAT-M1 eFDD 25 QPSK | mid | 3 | 1.4 | 21.28 | 2 | 2 | 11.72 | 11.72 |
| CAT-M1 eFDD 25 QPSK | mid | 6 | 1.4 | 20.37 | 2 | 2 | 12.63 | 12.63 |
| CAT-M1 eFDD 25 QPSK | high | 1 | 1.4 | 22.08 | 2 | 2 | 10.92 | 10.92 |
| CAT-M1 eFDD 25 QPSK | high | 3 | 1.4 | 21.75 | 2 | 2 | 11.25 | 11.25 |
| CAT-M1 eFDD 25 QPSK | high | 6 | 1.4 | 20.49 | 2 | 2 | 12.51 | 12.51 |
| CAT-M1 eFDD 25 16QAM | low | 1 | 1.4 | 20.84 | 2 | 2 | 12.16 | 12.16 |
| CAT-M1 eFDD 25 16QAM | low | 5 | 1.4 | 20.16 | 2 | 2 | 12.84 | 12.84 |
| CAT-M1 eFDD 25 16QAM | mid | 1 | 1.4 | 20.71 | 2 | 2 | 12.29 | 12.29 |
| CAT-M1 eFDD 25 16QAM | mid | 5 | 1.4 | 20.01 | 2 | 2 | 12.99 | 12.99 |
| CAT-M1 eFDD 25 16QAM | high | 1 | 1.4 | 20.09 | 2 | 2 | 12.91 | 12.91 |
| CAT-M1 eFDD 25 16QAM | high | 5 | 1.4 | 20.30 | 2 | 2 | 12.7 | 12.7 |
| NB-IoT eFDD 2 QPSK | low | 1 | 0.2 | 23.04 | 2 | 2 | 9.96 | 9.96 |
| NB-IoT eFDD 2 QPSK | low | 3 | 0.2 | 23.62 | 2 | 2 | 9.38 | 9.38 |
| NB-IoT eFDD 2 QPSK | low | 6 | 0.2 | 22.61 | 2 | 2 | 10.39 | 10.39 |
| NB-IoT eFDD 2 QPSK | low | 12 | 0.2 | 21.49 | 2 | 2 | 11.51 | 11.51 |
| NB-IoT eFDD 2 QPSK | mid | 1 | 0.2 | 24.27 | 2 | 2 | 8.73 | 8.73 |
| NB-IoT eFDD 2 QPSK | mid | 3 | 0.2 | 23.77 | 2 | 2 | 9.23 | 9.23 |
| NB-IoT eFDD 2 QPSK | mid | 6 | 0.2 | 22.62 | 2 | 2 | 10.38 | 10.38 |
| NB-IoT eFDD 2 QPSK | mid | 12 | 0.2 | 21.12 | 2 | 2 | 11.88 | 11.88 |
| NB-IoT eFDD 2 QPSK | high | 1 | 0.2 | 24.25 | 2 | 2 | 8.75 | 8.75 |
| NB-IoT eFDD 2 QPSK | high | 3 | 0.2 | 23.83 | 2 | 2 | 9.17 | 9.17 |
| NB-IoT eFDD 2 QPSK | high | 6 | 0.2 | 22.60 | 2 | 2 | 10.4 | 10.4 |
| NB-IoT eFDD 2 QPSK | high | 12 | 0.2 | 20.94 | 2 | 2 | 12.06 | 12.06 |
| NB-IoT eFDD 2 BPSK | low | 1 | 0.2 | 23.02 | 2 | 2 | 9.98 | 9.98 |
| NB-IoT eFDD 2 BPSK | mid | 1 | 0.2 | 23.08 | 2 | 2 | 9.92 | 9.92 |
| NB-IoT eFDD 2 BPSK | high | 1 | 0.2 | 23.51 | 2 | 2 | 9.49 | 9.49 |

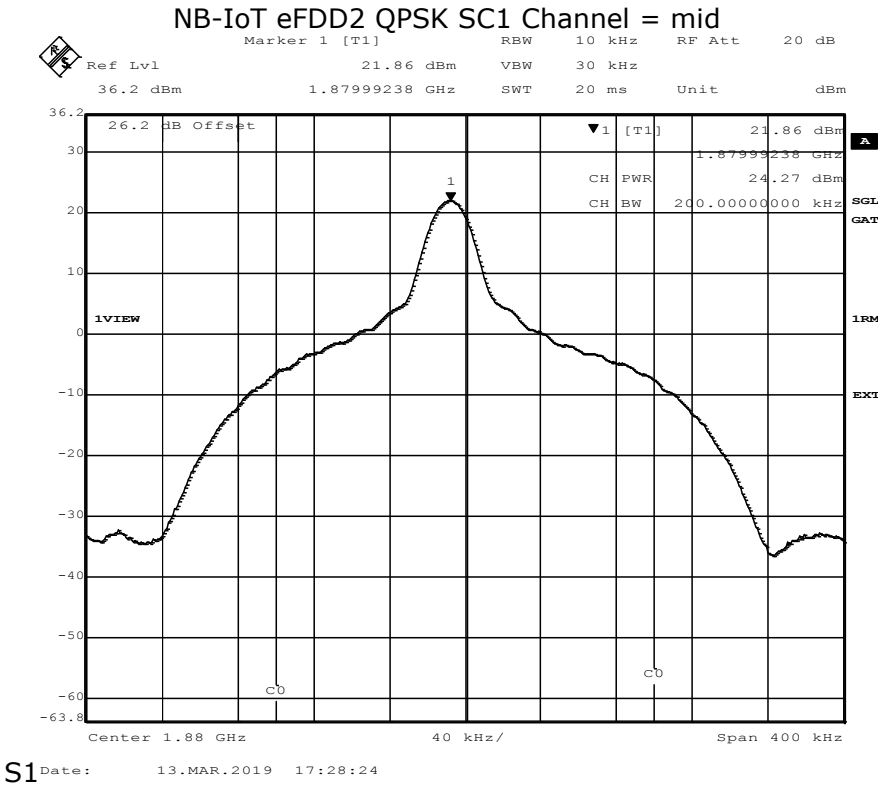
Remark: Please see next sub-clause for the measurement plot.

## 5.1.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

CAT-M1 eFDD2 QPSK 1 RB Channel = mid




NB-IoT eFDD2 QPSK SC1 Channel = mid




S1

## 5.1.5 TEST EQUIPMENT USED

- Radio Lab

## 5.2 FREQUENCY STABILITY

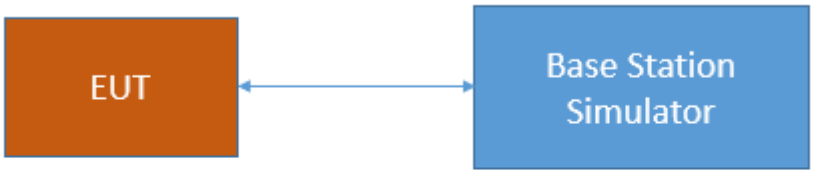
Standard **FCC PART 24 Subpart E**

**The test was performed according to:**
ANSI C63.26: 2015

### 5.2.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable frequency stability test case per § 2.1055 and RSS-GEN 6.11. The limit and the requirements come from the applicable rule part and ISED RSS-Standard for the operating band of the cellular device.

The EUT was connected to the test setup according to the following diagram:




Test Setup FCC Part 22/24/27/90 Cellular; Frequency stability

The attenuation of the measuring / stimulus path is known for each measured frequency and are considered.

### 5.2.2 TEST REQUIREMENTS / LIMITS

**FCC Part 24, § 24.235**

The frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block.

**RSS-133; 6.3 Frequency Stability**

The carrier frequency shall not depart from the reference frequency, in excess of ±2.5 ppm for mobile stations.

In lieu of meeting the above stability values, the test report may show that the frequency stability is sufficient to ensure that the emission bandwidth stays within the operating frequency block when tested to the temperature and supply voltage variations specified in RSS-Gen.

## 5.2.3 TEST PROTOCOL

LTE CAT-M1 eFDD2

| Temp. °C | Duration min | Voltage | Limit Hz | Freq. error Average (Hz) | Freq. error Max. (Hz) | Verdict |
|---|---|---|---|---|---|---|
| -30 | 0 | normal | 4700 | 1.3 | 3.4 | passed |
| -30 | 5 | | | 1.4 | 3.9 | passed |
| -30 | 10 | | | 1.4 | 4.5 | passed |
| -20 | 0 | normal | 4700 | 1.3 | 4.3 | passed |
| -20 | 5 | | | 1.2 | 3.7 | passed |
| -20 | 10 | | | 1.3 | 5.1 | passed |
| -10 | 0 | normal | 4700 | 1.6 | 5.2 | passed |
| -10 | 5 | | | 1.4 | 5.3 | passed |
| -10 | 10 | | | 1.5 | 4 | passed |
| 0 | 0 | normal | 4700 | 1.6 | 4.6 | passed |
| 0 | 5 | | | 1.2 | 4.8 | passed |
| 0 | 10 | | | 1.8 | 4.3 | passed |
| 10 | 0 | normal | 4700 | 1.9 | 4.9 | passed |
| 10 | 5 | | | 1.7 | 4.7 | passed |
| 10 | 10 | | | 1.6 | 4.7 | passed |
| 20 | 0 | low | 4700 | 1.2 | 4.4 | passed |
| 20 | 5 | | | 1.4 | 4.7 | passed |
| 20 | 10 | | | 1.4 | 4.4 | passed |
| 20 | 0 | normal | 4700 | 1.4 | 3.7 | passed |
| 20 | 5 | | | 1.6 | 3.8 | passed |
| 20 | 10 | | | 1.6 | 3.4 | passed |
| 20 | 0 | high | 4700 | 1.2 | 4.2 | passed |
| 20 | 5 | | | 1.6 | 4.4 | passed |
| 20 | 10 | | | 1.4 | 4.7 | passed |
| 30 | 0 | normal | 4700 | 1.3 | 4.6 | passed |
| 30 | 5 | | | 0.9 | 4.3 | passed |
| 30 | 10 | | | 1.1 | 4.8 | passed |
| 40 | 0 | normal | 4700 | 1.5 | 5.1 | passed |
| 40 | 5 | | | 0.7 | 4.9 | passed |
| 40 | 10 | | | 0.9 | 4.6 | passed |
| 50 | 0 | normal | 4700 | 1.5 | 4.4 | passed |
| 50 | 5 | | | 1.6 | 4.2 | passed |
| 50 | 10 | | | 1.6 | 3.6 | passed |

LTE CAT-M1 eFDD25

| Temp. °C | Duration min | Voltage | Limit Hz | Freq. error Average (Hz) | Freq. error Max. (Hz) | Verdict |
|---|---|---|---|---|---|---|
| -30 | 0 | normal | 4700 | 1.3 | 3.6 | passed |
| -30 | 5 | | | 1.4 | 4.7 | passed |
| -30 | 10 | | | 1.8 | 4.1 | passed |
| -20 | 0 | normal | 4700 | 1.7 | 4.6 | passed |
| -20 | 5 | | | 1.7 | 5.1 | passed |
| -20 | 10 | | | 1.6 | 5.7 | passed |
| -10 | 0 | normal | 4700 | 1.4 | 6 | passed |
| -10 | 5 | | | 1.8 | 6.7 | passed |
| -10 | 10 | | | 1.6 | 6.2 | passed |
| 0 | 0 | normal | 4700 | 1.4 | 4.9 | passed |
| 0 | 5 | | | 1.5 | 5.1 | passed |
| 0 | 10 | | | 1.5 | 5.9 | passed |
| 10 | 0 | normal | 4700 | 1.4 | 5.6 | passed |
| 10 | 5 | | | 1.3 | 4.2 | passed |
| 10 | 10 | | | 1.8 | 4.3 | passed |
| 20 | 0 | low | 4700 | 1.4 | 4.2 | passed |
| 20 | 5 | | | 1.2 | 4.4 | passed |
| 20 | 10 | | | 1.4 | 4.8 | passed |
| 20 | 0 | normal | 4700 | 1.5 | 5.2 | passed |
| 20 | 5 | | | 1.6 | 4.8 | passed |
| 20 | 10 | | | 1.9 | 4.9 | passed |
| 20 | 0 | high | 4700 | 1.4 | 4.4 | passed |
| 20 | 5 | | | 1.6 | 4.7 | passed |
| 20 | 10 | | | 1.3 | 4.8 | passed |
| 30 | 0 | normal | 4700 | 1.1 | 5.2 | passed |
| 30 | 5 | | | 1.3 | 5.6 | passed |
| 30 | 10 | | | 1.2 | 5.4 | passed |
| 40 | 0 | normal | 4700 | 0.9 | 5.8 | passed |
| 40 | 5 | | | 1 | 6.2 | passed |
| 40 | 10 | | | 1.4 | 4.9 | passed |
| 50 | 0 | normal | 4700 | 1.6 | 5.7 | passed |
| 50 | 5 | | | 1.7 | 4.6 | passed |
| 50 | 10 | | | 1.5 | 6.9 | passed |

NB-IoT eFDD2

| Temp. °C | Duration min | Voltage | Limit Hz | Freq. error Average (Hz) | Freq. error Max. (Hz) | Verdict |
|---|---|---|---|---|---|---|
| -30 | 0 | normal | 4700 | -5.8 | -11.4 | passed |
| -30 | 5 | | | -3.9 | -11.1 | passed |
| -30 | 10 | | | -5.2 | -11.6 | passed |
| -20 | 0 | normal | 4700 | -4.3 | -11.4 | passed |
| -20 | 5 | | | -3.9 | -11.3 | passed |
| -20 | 10 | | | -4.8 | -11.7 | passed |
| -10 | 0 | normal | 4700 | -5.1 | -11.6 | passed |
| -10 | 5 | | | -4.6 | -11.9 | passed |
| -10 | 10 | | | -4.2 | -11.3 | passed |
| 0 | 0 | normal | 4700 | -3.6 | -11.7 | passed |
| 0 | 5 | | | -3.8 | -11.5 | passed |
| 0 | 10 | | | -4.8 | -11.5 | passed |
| 10 | 0 | normal | 4700 | -5.3 | -11.1 | passed |
| 10 | 5 | | | -4.5 | -11.2 | passed |
| 10 | 10 | | | -4.7 | -11.4 | passed |
| 20 | 0 | low | 4700 | -4.2 | -11.1 | passed |
| 20 | 5 | | | -3.8 | -11.4 | passed |
| 20 | 10 | | | -4 | -11.6 | passed |
| 20 | 0 | normal | 4700 | -4.2 | -11 | passed |
| 20 | 5 | | | -4.7 | -11.3 | passed |
| 20 | 10 | | | -5.8 | -11.4 | passed |
| 20 | 0 | high | 4700 | -5.2 | -11.6 | passed |
| 20 | 5 | | | -4.8 | -11.4 | passed |
| 20 | 10 | | | -5 | -11.2 | passed |
| 30 | 0 | normal | 4700 | -4.4 | -13 | passed |
| 30 | 5 | | | -3.1 | -9.4 | passed |
| 30 | 10 | | | -3.8 | -9.6 | passed |
| 40 | 0 | normal | 4700 | -4.1 | -12.6 | passed |
| 40 | 5 | | | -3.8 | -10.9 | passed |
| 40 | 10 | | | -3.6 | -11.1 | passed |
| 50 | 0 | normal | 4700 | -2.7 | -9.4 | passed |
| 50 | 5 | | | -2.8 | -11.3 | passed |
| 50 | 10 | | | -3.5 | -10.5 | passed |

### 5.2.4 TEST EQUIPMENT USED

- Radio Lab

## 5.3 SPURIOUS EMISSIONS AT ANTENNA TERMINAL

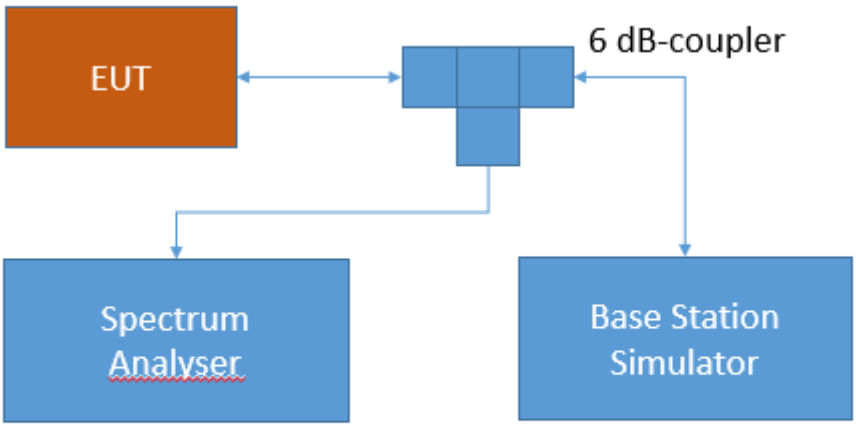
Standard **FCC PART 24 Subpart E**

**The test was performed according to:**
ANSI C63.26: 2015

### 5.3.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable conducted spurious emission test case per § 2.1051 and RSS-GEN 6.13. The limit comes from the applicable rule part and ISED RSS-Standard for the operating band of the cellular device.

The EUT was connected to the test setup according to the following diagram:




Test Setup FCC Part 22/24/27/90 Cellular;
Spurious Emissions at antenna terminal

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

### 5.3.2 TEST REQUIREMENTS / LIMITS

**FCC Part 2.1051; Measurement required: Spurious emissions at antenna terminal:**

The radio frequency voltage or powers 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 §2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

**Part 24, Subpart E – Broadband PCS; Band 2**

**§24.238 – Emission limitations for Broadband PCS equipment**

*(a) Out of band emissions.* 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.

**RSS-133; 6.5 Transmitter Unwanted Emissions**

**6.5.1 Out-of-Block Emissions**

Equipment shall comply with the limits in (i) and (ii) below.

i. In the 1.0 MHz bands immediately outside and adjacent to the equipment's operating frequency block, the emission power per any 1% of the emission bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10p(watts).
ii. After the first 1.0 MHz, the emission power in any 1 MHz bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10p(watts). If the measurement is performed using 1% of the emission bandwidth, power integration over 1.0 MHz is required.

## 5.3.3 TEST PROTOCOL

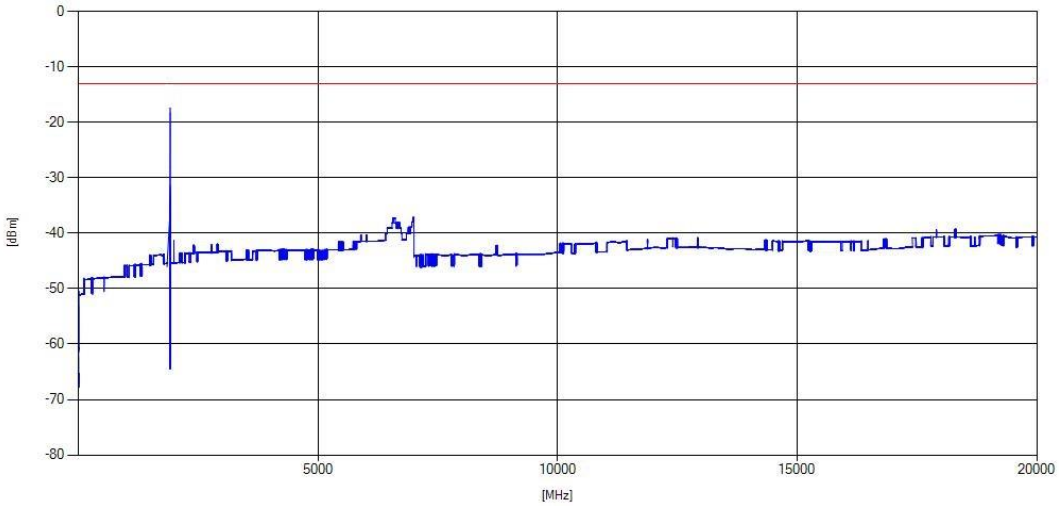
Ambient temperature: 23 °C Relative humidity: 34 %

| Radio Technology | CH | Detector | Trace | Resolution Bandwidth /kHz | Frequency /MHz | Peak Value /dBm | Limit /dBm | Margin to Limit /dB |
|---|---|---|---|---|---|---|---|---|
| CAT-M1 eFDD 2 QPSK | low | rms | maxhold | 5 | 1849.99 | -38.54 | -17.5 | 21.04 |
| CAT-M1 eFDD 2 QPSK | mid | - | - | - | - | - | -13 | >20 |
| CAT-M1 eFDD 2 QPSK | high | rms | maxhold | 5 | 1910.01 | -34.86 | -17.5 | 17.36 |
| CAT-M1 eFDD 2 QPSK | high | rms | maxhold | 1000 | 1912.18 | -18.25 | -13 | 5.25 |
| CAT-M1 eFDD 25 QPSK | low | rms | maxhold | 5 | 1849.99 | -34.76 | -17.5 | 17.26 |
| CAT-M1 eFDD 25 QPSK | mid | - | - | - | - | - | -13 | >20 |
| CAT-M1 eFDD 25 QPSK | high | rms | maxhold | 5 | 1915.01 | 34.86 | -17.5 | 17.36 |
| NB-IoT eFDD 2 QPSK | low | rms | maxhold | 2 | 1850.0 | -21.3 | -13 | 8.3 |
| NB-IoT eFDD 2 QPSK | mid | - | - | - | - | - | -13 | >20 |
| NB-IoT eFDD 2 QPSK | high | rms | maxhold | 1000 | 1912.35 | -30.84 | -13 | 17.84 |

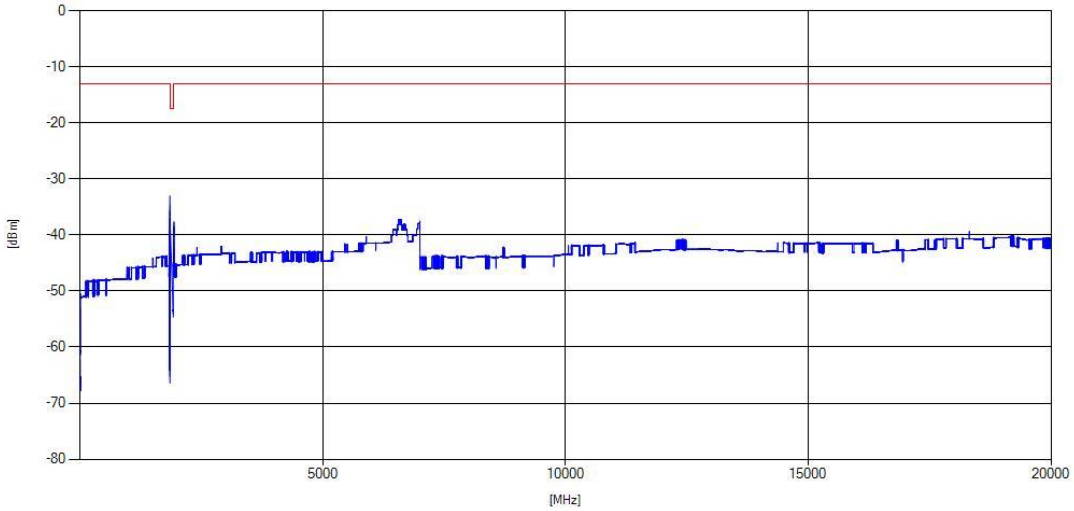
Remark: Please see next sub-clause for the measurement plot.

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

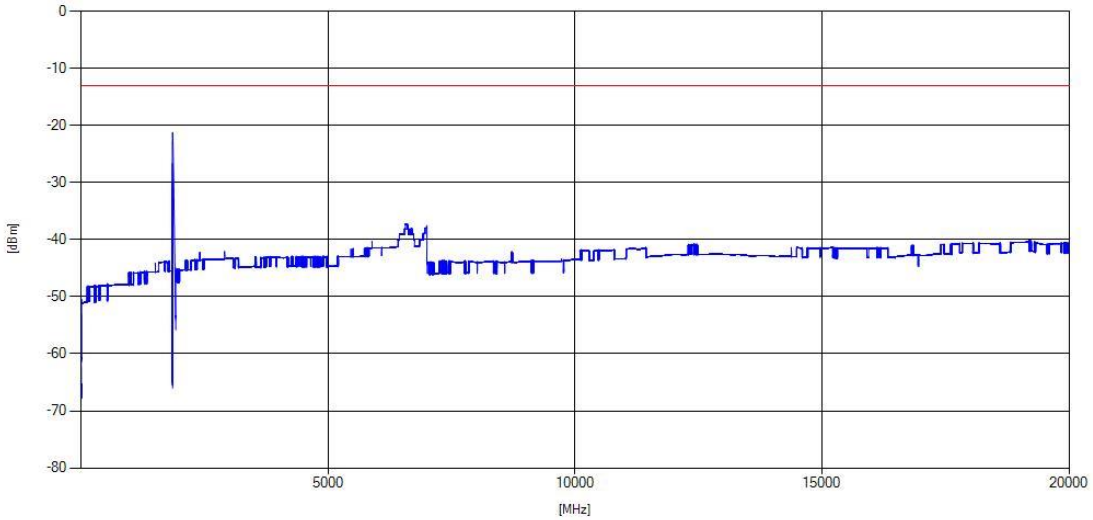
CAT-M1 eFDD2 Channel = high



CAT-M1 eFDD25 Channel = low




NB-IoT eFDD2 Channel = low




## 5.3.5 TEST EQUIPMENT USED

- Radio Lab

## 5.4 FIELD STRENGTH OF SPURIOUS RADIATION

Standard **FCC PART 24 Subpart E**

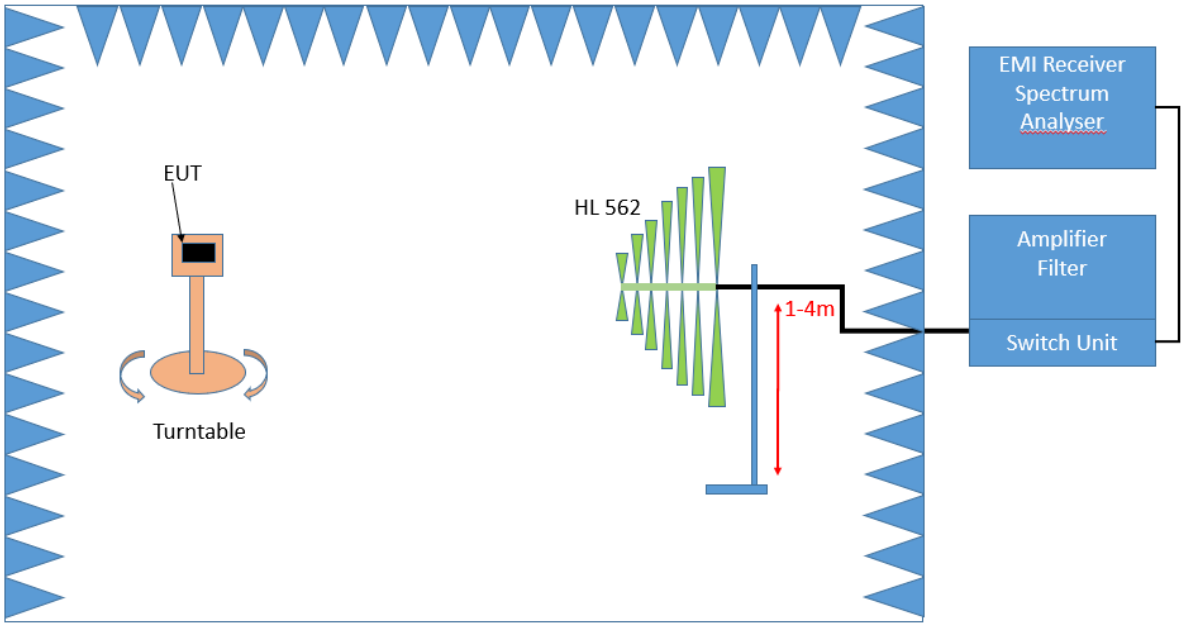
**The test was performed according to:**
ANSI C63.26: 2015

### 5.4.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable radiated spurious emission measurements per § 2.1053 and RSS-GEN 6.13. The limit and requirements come from the applicable rule part and ISED RSS-Standard for the operating band of the cellular device.

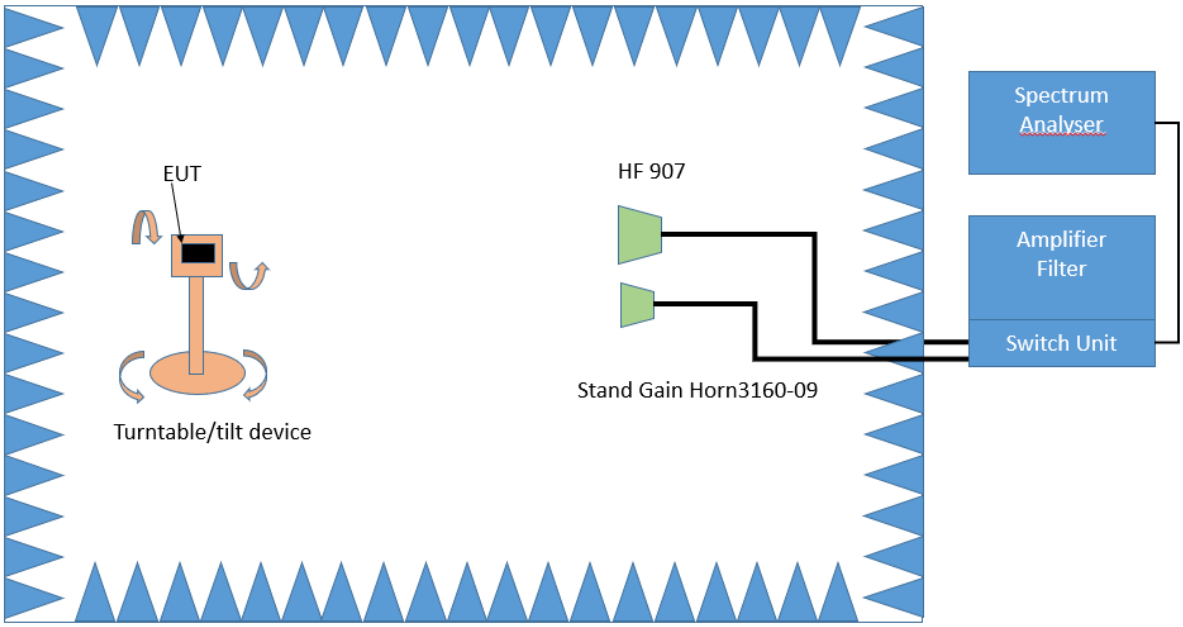
The EUT was connected to the test setup according to the following diagram:

Frequency Range: 30 MHz – 1 GHz:




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

Frequency Range: 1 GHz – 26.5 GHz




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

The test set-up was made in accordance to the general provisions of ANSI C63.26 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m² 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 above 30 MHz and up to 1 GHz**

**Step 1:** Preliminary scan
This is a preliminary test to identify the highest amplitudes relative to the limit.
Settings for step 1:
- Antenna distance: 3 m
- Detector: Peak
- RBW: 1000 kHz
- VBW: 3000 kHz
- Sweep time: coupled
- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- 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 ± 45° 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 ± 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
- Measured frequencies: in step 1 determined frequencies
- RBW: 1000 kHz
- VBW: 3000 kHz
- Sweep time: coupled
- Turntable angle range: ± 45 ° around the determined value
- Height variation range: ± 100 cm 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 3, the final measurement will be performed:
EMI receiver settings for step 4:
- Detector: RMQ
- Measured frequencies: in step 1 determined frequencies
- RBW: 1000 kHz
- VBW: 3000 kHz
- Sweep 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 above 1 GHz**
The following modifications apply to the measurement procedure for the frequency range above 1 GHz:
**Step 1:**
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 EUT is turned during the preliminary measurement across the elevation axis, with a step size of 90 °.
The turn table step size (azimuth angle) for the preliminary measurement is 45 °.
- Antenna distance: 3 m
- Detector: Peak
- RBW: 1 MHz
- VBW: 3 MHz
- Sweep time: coupled
- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- Polarisation: Horizontal + Vertical

**Step 2:**
Due to the fact, that in this frequency range the test is performed in a fully anechoic room, the height scan of the receiving antenna instep 2 is omitted. Instead of this, a maximum search with a step size ± 45° for the elevation axis is performed.
The turn table azimuth will slowly vary by ± 22.5°.
The elevation angle will slowly vary by ± 45°
EMI receiver settings (for all steps):
- Detector: Peak,
- RBW: 1 MHz
- VBW: 3 MHz
- Sweep time: coupled

**Step 3:**
Spectrum analyser settings for step 3:
- Detector: RMS
- Measured frequencies: in step 1 determined frequencies
- RBW: 1 MHz
- VBW: 3 MHz
- Sweep Time: 1 s

## 5.4.2 TEST REQUIREMENTS / LIMITS

**FCC Part 2.1053; Measurement 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 §2.1049, as appropriate.

**Part 24, Subpart E – Broadband PCS**

**§ 24 238 – Emission limitations for Broadband PCS equipment**

a) Out of band emissions. 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.

b) Measurement procedure. Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 1 MHz or greater. However, 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. 1 MHz 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.

**RSS-133; 6.5 Transmitter Unwanted Emissions**

Mobile and base station equipment shall comply with the limits in (1) and (2) below.

1. In the 1.0 MHz bands immediately outside and adjacent to the equipment's operating frequency block, the emission power per any 1% of the emission bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 $\log_{10}$p (watts).
2. After the first 1.0 MHz, the emission power in any 1 MHz bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 $\log_{10}$p (watts). If the measurement is performed using 1% of the emission bandwidth, power integration over 1.0 MHz is required.

### 5.4.3 TEST PROTOCOL

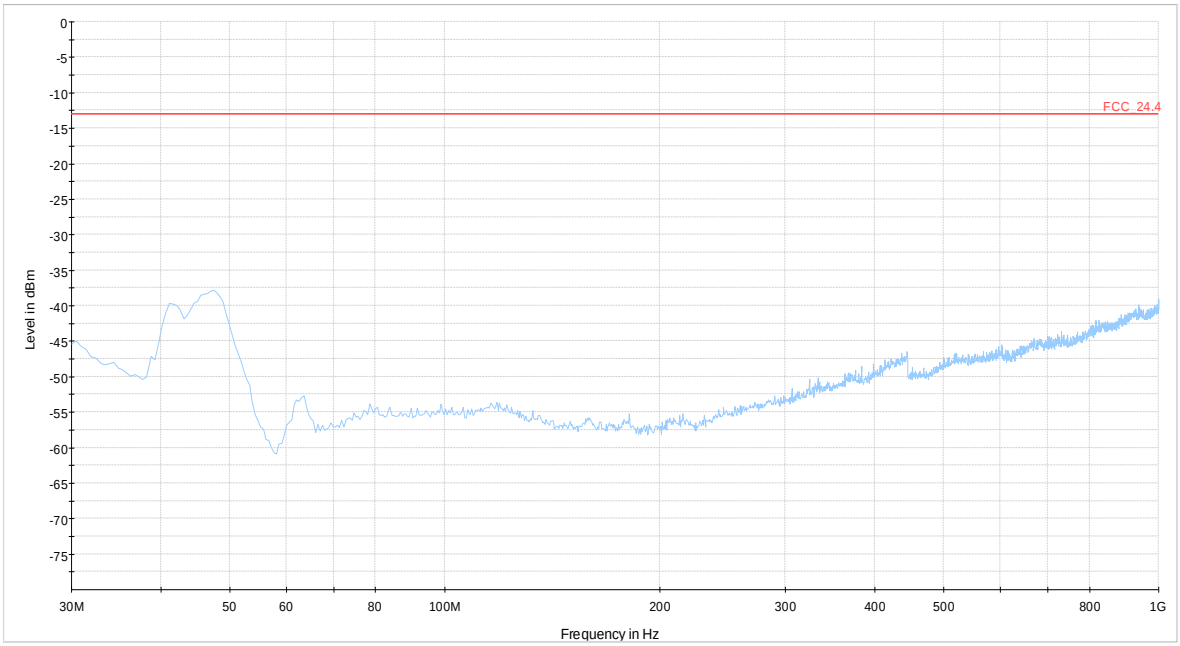
Ambient temperature: 22 °C Relative humidity: 32 %

| Radio Technology | CH | Detector | Trace | Resolution Bandwidth /kHz | Frequency /MHz | Peak Value /dBm | Limit /dBm | Margin to Limit /dB |
|---|---|---|---|---|---|---|---|---|
| CAT-M1 eFDD 2 QPSK | low | rms | maxhold | 5 | 1848.92 | -30.05 | -17.5 | 12.55 |
| CAT-M1 eFDD 2 QPSK | mid | - | - | - | - | - | -13 | >20 |
| CAT-M1 eFDD 2 QPSK | high | rms | maxhold | 5 | 1911.68 | -29.15 | -17.5 | 11.65 |
| CAT-M1 eFDD 25 QPSK | low | rms | maxhold | 10 | 1848.53 | -25.4 | -14.5 | 10.9 |
| CAT-M1 eFDD 25 QPSK | mid | peak | maxhold | 1000 | 1960.67 | -27.35 | -13 | 14.35 |
| CAT-M1 eFDD 25 QPSK | high | rms | maxhold | 10 | 1917.36 | -32.7 | -14.5 | 18.2 |
| NB-IoT eFDD 2 QPSK | low | peak | maxhold | 20 | 1849.59 | -18.3 | -13 | 5.28 |
| NB-IoT eFDD 2 QPSK | mid | - | - | - | - | - | - | >20 |
| NB-IoT eFDD 2 QPSK | high | peak | maxhold | 20 | 1910.24 | -17.0 | -13 | 4.06 |

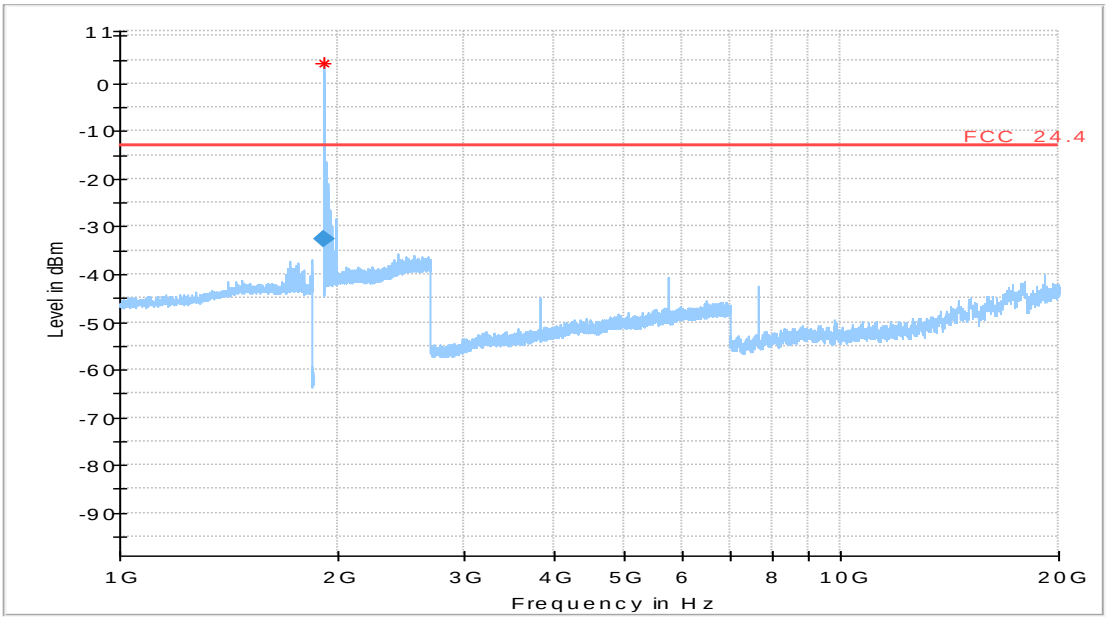
Remark: Please see next sub-clause for the measurement plot.

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

CAT-M1 eFDD25 QPSK Channel = high
30 MHz – 1 GHz

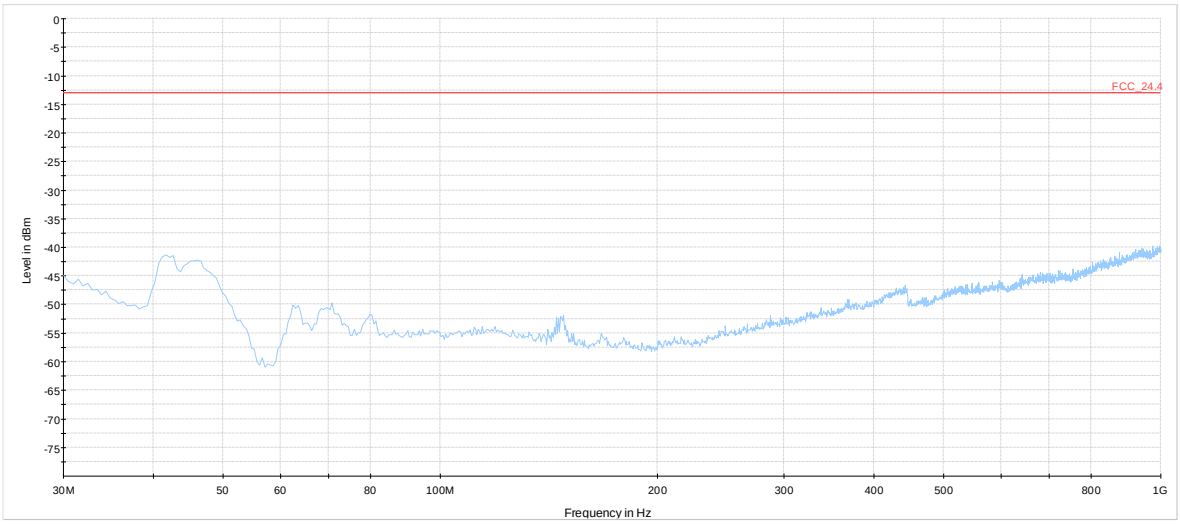



CAT-M1 eFDD25 QPSK Channel = high
1 GHz – 20 GHz

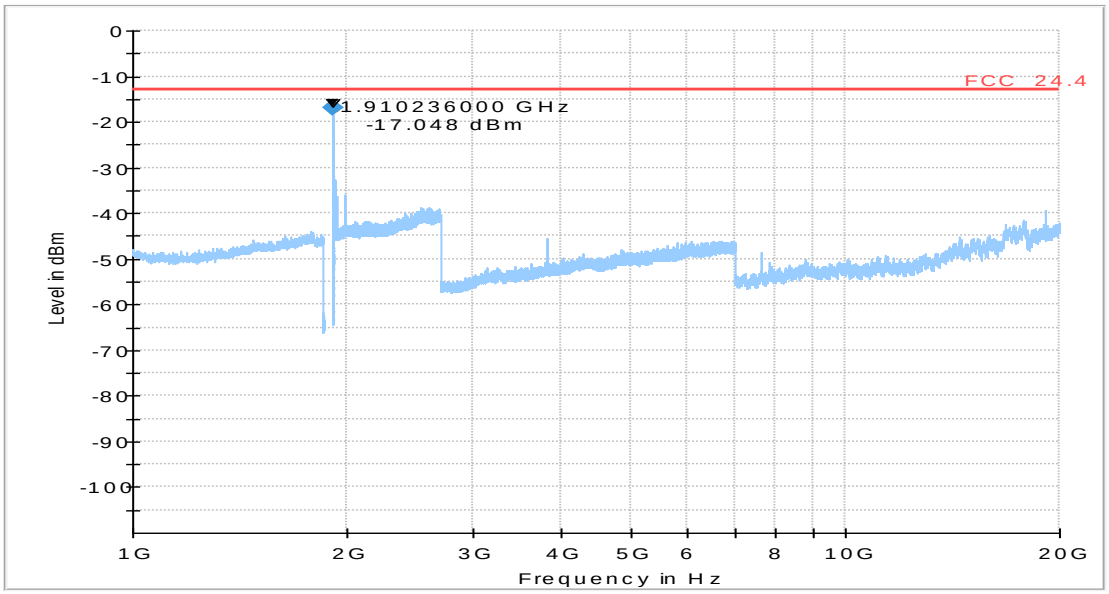



| Frequency (MHz) | RMS (dBm) | Limit (dBm) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Elevation (deg) | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1917.364 | -32.7 | -14.50 | 18.2 | 1000.0 | 10.000 | 150.0 | V | -185.0 | 91.0 | -64.7 |

NB-IoT eFDD2 QPSK Channel = high
30 MHz – 1 GHz




NB-IoT eFDD2 QPSK Channel = high
1 GHz – 20 GHz




| Frequency (MHz) | MaxPeak (dBm) | Limit (dBm) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Elevation (deg) | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1910.236 | -17.0 | -13.00 | 4.05 | 1000.0 | 20.000 | 150.0 | V | -180.0 | 90.0 | -64.7 |

## 5.4.5 TEST EQUIPMENT USED

- Radiated Emissions

## 5.5 EMISSION AND OCCUPIED BANDWIDTH

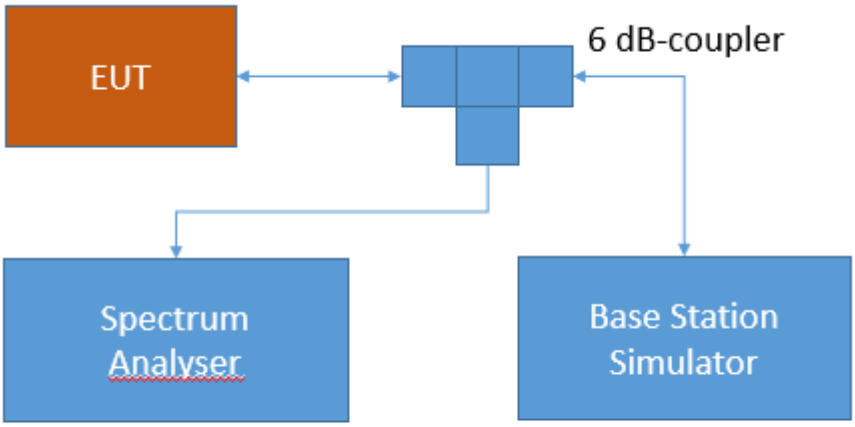
Standard **FCC PART 24 Subpart E**

**The test was performed according to:**
ANSI C63.26: 2015

### 5.5.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable conducted spurious emission test case per FCC §2.1049 and RSS-GEN 6.7. The limit and the requirements come from the applicable rule part and ISED RSS-Standard for the operating band of the cellular device.

The EUT was connected to the test setups according to the following diagram:




Test Setup FCC Part 22/24/27/90 Cellular;

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

### 5.5.2 TEST REQUIREMENTS / LIMITS

**FCC Part 2.1049; 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.

(i) Transmitters designed for other types of modulation—when modulated by an appropriate signal of sufficient amplitude to be representative of the type of service in which used. A description of the input signal should be supplied.

**RSS-GEN; 6.7 Occupied Bandwidth (or 99% emission bandwidth) and x dB bandwidth**

The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

In some cases, the "x dB bandwidth" is required, which is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated x dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

The following conditions shall be observed for measuring the occupied bandwidth and x dB bandwidth:

The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.
The detector of the spectrum analyzer shall be set to "Sample". However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or "Max Hold") may be necessary to determine the occupied / x dB bandwidth if the device is not transmitting continuously.
The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then

recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

### 5.5.3 TEST PROTOCOL

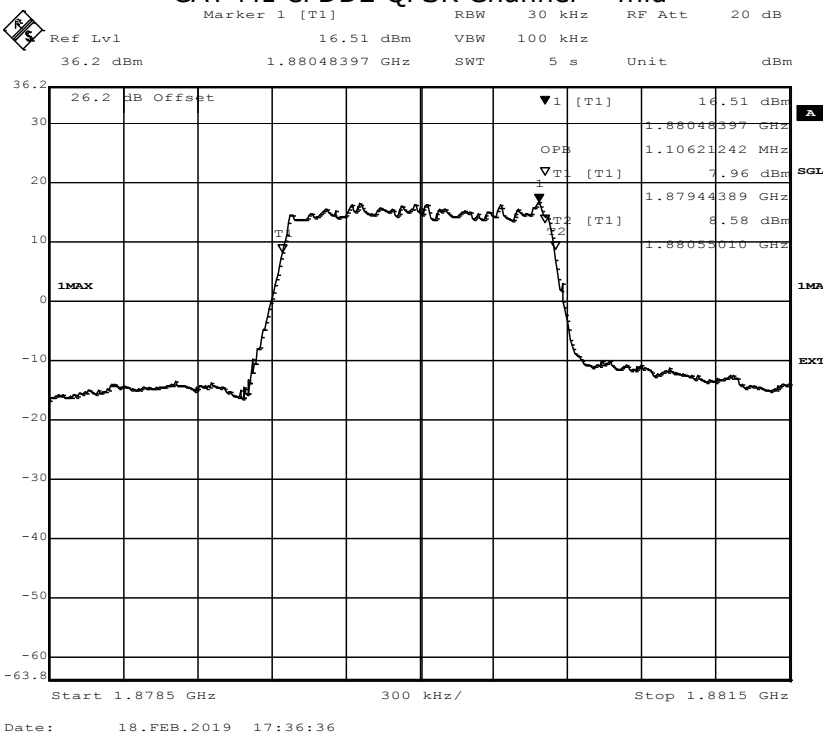
Ambient temperature: 23 °C
Relative humidity: 34 %

| Radio Technology | Channel | Ressource Blocks / Subcarrier | Bandwidth [MHz] | Nominal BW [MHz] | 99 % BW [kHz] |
|---|---|---|---|---|---|
| CAT-M1 eFDD 2 QPSK | low | 6 | 1.4 | 1.4 | 1106.21 |
| CAT-M1 eFDD 2 QPSK | mid | 6 | 1.4 | 1.4 | 1106.21 |
| CAT-M1 eFDD 2 QPSK | high | 6 | 1.4 | 1.4 | 1106.21 |
| CAT-M1 eFDD 2 16QAM | low | 5 | 1.4 | 1.4 | 931.86 |
| CAT-M1 eFDD 2 16QAM | mid | 5 | 1.4 | 1.4 | 937.88 |
| CAT-M1 eFDD 2 16QAM | high | 5 | 1.4 | 1.4 | 937.88 |
| CAT-M1 eFDD 25 QPSK | low | 6 | 1.4 | 1.4 | 1106.21 |
| CAT-M1 eFDD 25 QPSK | mid | 6 | 1.4 | 1.4 | 1100.2 |
| CAT-M1 eFDD 25 QPSK | high | 6 | 1.4 | 1.4 | 1112.22 |
| CAT-M1 eFDD 25 16QAM | low | 5 | 1.4 | 1.4 | 961.92 |
| CAT-M1 eFDD 25 16QAM | mid | 5 | 1.4 | 1.4 | 943.89 |
| CAT-M1 eFDD 25 16QAM | high | 5 | 1.4 | 1.4 | 949.9 |
| NB-IoT eFDD 2 QPSK | low | 12 | 0.2 | 0.2 | 192.38 |
| NB-IoT eFDD 2 QPSK | mid | 12 | 0.2 | 0.2 | 192.38 |
| NB-IoT eFDD 2 QPSK | high | 12 | 0.2 | 0.2 | 192.38 |
| NB-IoT eFDD 2 BPSK | low | 1 | 0.2 | 0.2 | 78.16 |
| NB-IoT eFDD 2 BPSK | mid | 1 | 0.2 | 0.2 | 78.16 |
| NB-IoT eFDD 2 BPSK | high | 1 | 0.2 | 0.2 | 66.13 |

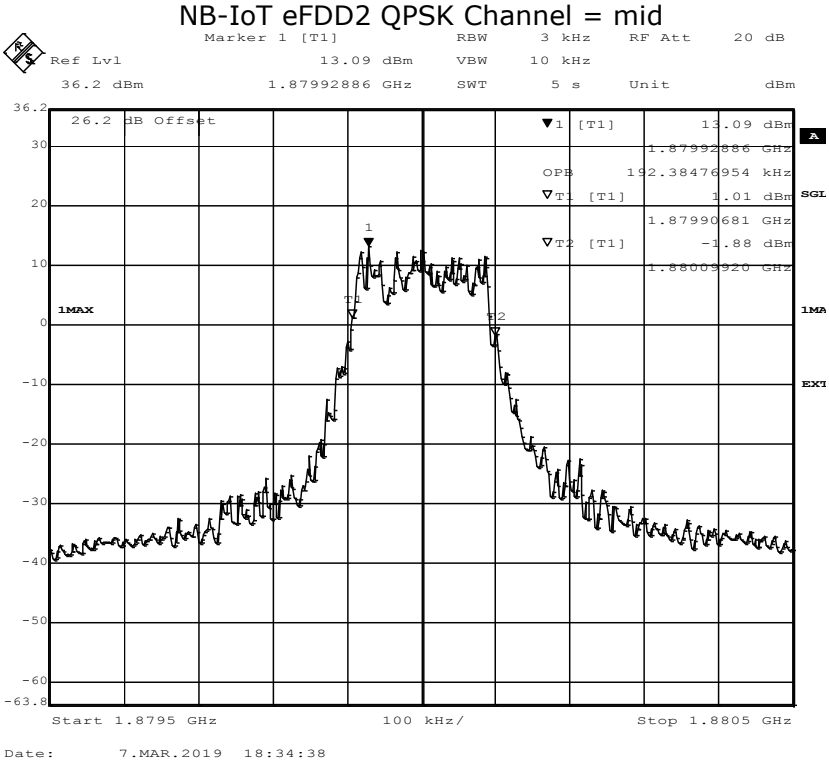
Remark: Please see next sub-clause for the measurement plot.

## 5.5.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

CAT-M1 eFDD2 QPSK Channel = mid




NB-IoT eFDD2 QPSK Channel = mid




## 5.5.5 TEST EQUIPMENT USED

- Radio Lab

## 5.6 BAND EDGE COMPLIANCE

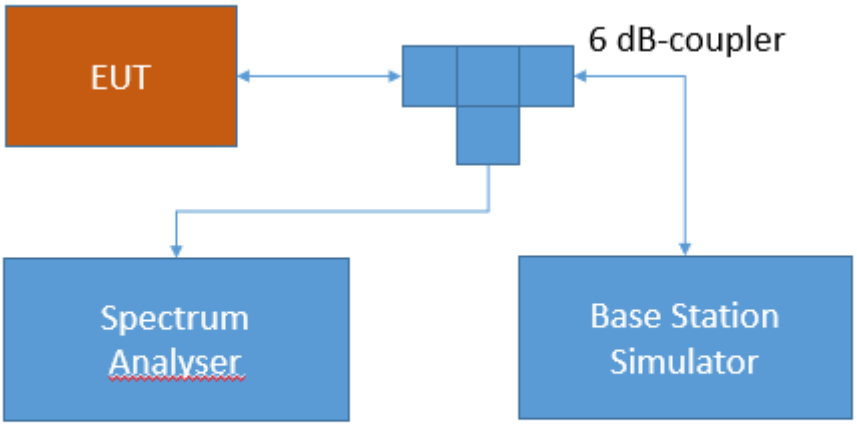
Standard **FCC PART 24 Subpart E**

**The test was performed according to:**
ANSI C63.26: 2015

### 5.6.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable conducted spurious emission test case per § 2. 1051 and RSS-GEN 6.13. The limit comes from the applicable rule part and ISED RSS-Standard for the operating band of the cellular device.

The EUT was connected to the test setup according to the following diagram:




Test Setup FCC Part 22/24/27/90 Cellular;
Band edge compliance

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

### 5.6.2 TEST REQUIREMENTS / LIMITS

**FCC Part 2.1051; Measurement required: Spurious emissions at antenna terminal:**

The radio frequency voltage or powers 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 §2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

**Part 24, Subpart E – Broadband PCS**

**§24 238 – Emission limitations for Broadband PCS equipment**

a) Out of band emissions. 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.

b) Measurement procedure. Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 1 MHz or greater. However, 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. 1 MHz 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.

**RSS-133; 6.5 Transmitter Unwanted Emissions**

Mobile and base station equipment shall comply with the limits in (1) and (2) below.

1. In the 1.0 MHz bands immediately outside and adjacent to the equipment's operating frequency block, the emission power per any 1% of the emission bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 $\log_{10}$p (watts).
2. After the first 1.0 MHz, the emission power in any 1 MHz bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 $\log_{10}$p (watts). If the measurement is performed using 1% of the emission bandwidth, power integration over 1.0 MHz is required.

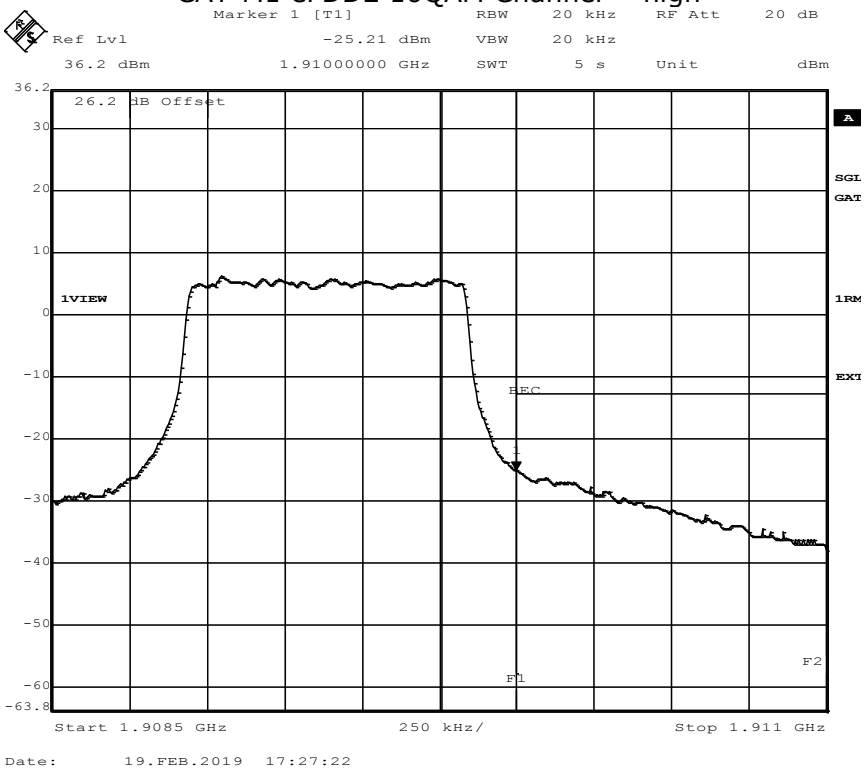
## 5.6.3 TEST PROTOCOL

| Radio Technology | Channel | Ressource Blocks / Subcarrier | Bandwidth [MHz] | Peak [dBm] | Average [dBm] | RMS [dBm] | Limit /dBm | Margin to Limit /dB |
|---|---|---|---|---|---|---|---|---|
| CAT-M1 eFDD 2 QPSK | low | 6 | 1.4 | -20.4 | -29.26 | -28.24 | -13 | 15.24 |
| CAT-M1 eFDD 2 QPSK | high | 6 | 1.4 | -15.92 | -28.74 | -26.9 | -13 | 13.9 |
| CAT-M1 eFDD 2 16QAM | low | 5 | 1.4 | -17.48 | -31.76 | -28.48 | -13 | 15.48 |
| CAT-M1 eFDD 2 16QAM | high | 5 | 1.4 | -15.29 | -26.7 | -25.21 | -13 | 12.21 |
| CAT-M1 eFDD 25 QPSK | low | 6 | 1.4 | -18.41 | -29.5 | -28.27 | -13 | 15.27 |
| CAT-M1 eFDD 25 QPSK | high | 6 | 1.4 | -16.04 | -28.98 | -26.8 | -13 | 13.8 |
| CAT-M1 eFDD 25 16QAM | low | 5 | 1.4 | -18.94 | -28.27 | -27.61 | -13 | 14.61 |
| CAT-M1 eFDD 25 16QAM | high | 5 | 1.4 | -18.01 | -27.61 | -26.61 | -13 | 13.61 |
| NB-IoT eFDD 2 QPSK | low | 12 | 0.2 | -7.51 | -31.76 | -19.72 | -13 | 6.72 |
| NB-IoT eFDD 2 QPSK | high | 12 | 0.2 | -3.33 | -25.92 | -15.96 | -13 | 2.96 |
| NB-IoT eFDD 2 BPSK | low | 1 | 0.2 | -19.61 | -24.25 | -23.24 | -13 | 10.24 |
| NB-IoT eFDD 2 BPSK | high | 1 | 0.2 | -19.97 | -24.4 | -24.25 | -13 | 11.25 |

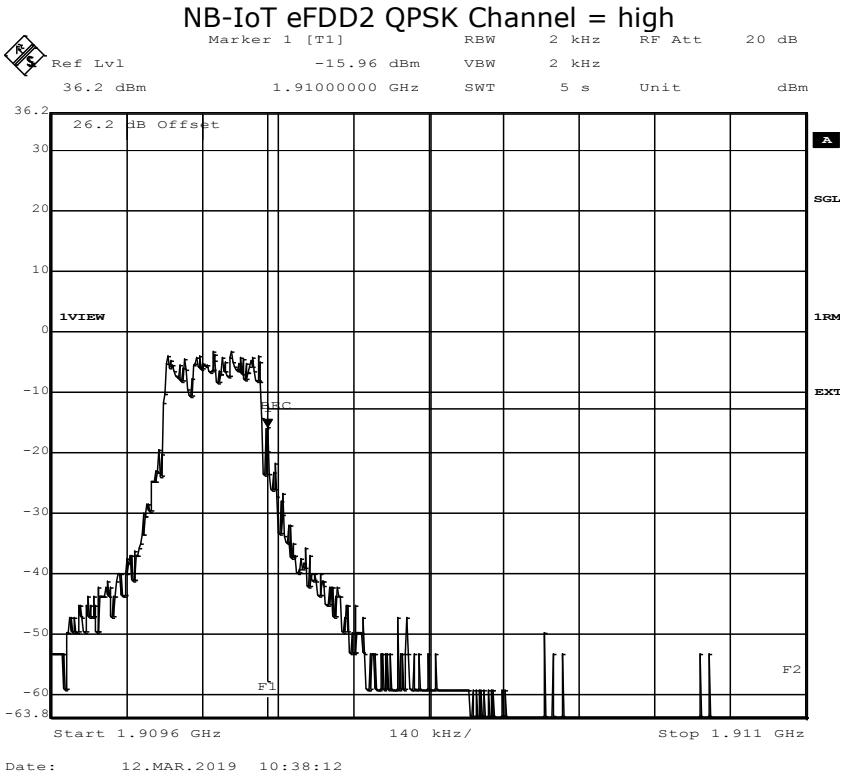
Remark: Please see next sub-clause for the measurement plot.

## 5.6.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

CAT-M1 eFDD2 16QAM Channel = high




NB-IoT eFDD2 QPSK Channel = high




## 5.6.5 TEST EQUIPMENT USED

- Radio Lab

## 5.7 PEAK TO AVERAGE RATIO

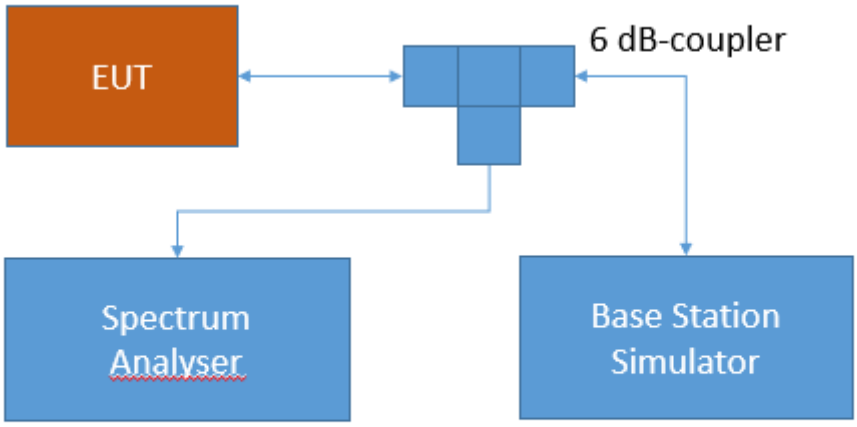
Standard **FCC PART 24 Subpart E**

**The test was performed according to:**
ANSI C63.26: 2015

### 5.7.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance of the EUT to the peak-to-average limits and requirements of the applicable rule part and ISED RSS-Standard for the operating band of the cellular device.

The EUT was connected to the test setup according to the following diagram:




Test Setup FCC Part 22/24/27/90 Cellular;
Peak-average ratio

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams. The internal CCDF (complementary cumulative distribution function) of the spectrum analyser is used for this measurement

### 5.7.2 TEST REQUIREMENTS / LIMITS

**FCC Part 24, § 24.232**

(d) Power measurements for transmissions by stations authorized under this section may be made either in accordance with a Commission-approved average power technique or in

compliance with paragraph (e) of this section. In both instances, equipment employed must be authorized in accordance with the provisions of §24.51. In measuring transmissions in this band using an average power technique, the peak-to-average ratio (PAR) of the transmission may not exceed 13 dB.

**RSS-133; 6.4 Transmitter Output Power and Equivalent Isotropically Radiated Power**

In addition, the peak-to-average power ratio (PAPR) of the transmitter shall not exceed 13 dB for more than 0.1% of the time using a signal corresponding to the highest PAPR during periods of continuous transmission.

### 5.7.3 TEST PROTOCOL

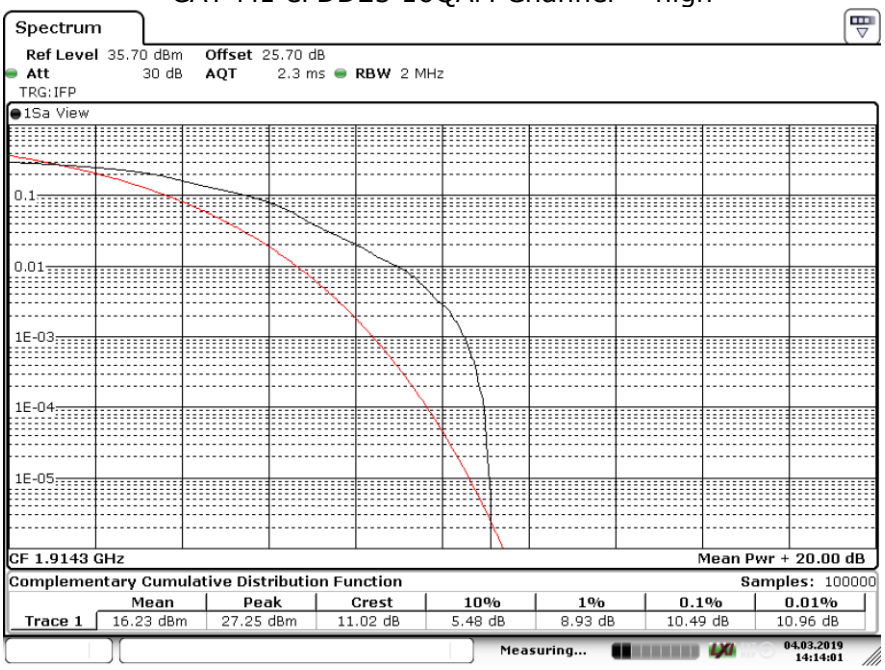
Ambient temperature: 23 °C
Relative humidity: 34 %

| Radio Technology | Channel | Ressource Blocks / Subcarrier | Bandwidth [MHz] | Peak to Average Ratio | Limit (IC) [dB] |
|---|---|---|---|---|---|
| CAT-M1 eFDD 2 QPSK | low | 6 | 1.4 | 8.93 | 13 |
| CAT-M1 eFDD 2 QPSK | mid | 6 | 1.4 | 9.22 | 13 |
| CAT-M1 eFDD 2 QPSK | high | 6 | 1.4 | 9.3 | 13 |
| CAT-M1 eFDD 2 16QAM | low | 5 | 1.4 | 10.12 | 13 |
| CAT-M1 eFDD 2 16QAM | mid | 5 | 1.4 | 10.29 | 13 |
| CAT-M1 eFDD 2 16QAM | high | 5 | 1.4 | 10.43 | 13 |
| CAT-M1 eFDD 25 QPSK | low | 6 | 1.4 | 8.93 | 13 |
| CAT-M1 eFDD 25 QPSK | mid | 6 | 1.4 | 9.1 | 13 |
| CAT-M1 eFDD 25 QPSK | high | 6 | 1.4 | 9.33 | 13 |
| CAT-M1 eFDD 25 16QAM | low | 5 | 1.4 | 9.83 | 13 |
| CAT-M1 eFDD 25 16QAM | mid | 5 | 1.4 | 10.26 | 13 |
| CAT-M1 eFDD 25 16QAM | high | 5 | 1.4 | 10.49 | 13 |
| NB-IoT eFDD 2 QPSK | low | 12 | 0.2 | 5.77 | 13 |
| NB-IoT eFDD 2 QPSK | mid | 12 | 0.2 | 5.8 | 13 |
| NB-IoT eFDD 2 QPSK | high | 12 | 0.2 | 5.91 | 13 |
| NB-IoT eFDD 2 BPSK | low | 1 | 0.2 | 2.49 | 13 |
| NB-IoT eFDD 2 BPSK | mid | 1 | 0.2 | 2.32 | 13 |
| NB-IoT eFDD 2 BPSK | high | 1 | 0.2 | 2.72 | 13 |

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

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

CAT-M1 eFDD25 16QAM Channel = high




Date: 4.MAR.2019 14:14:02

NB-IoT eFDD2 QPSK Channel = high

Date: 10.APR.2019 08:19:59

## 5.7.5 TEST EQUIPMENT USED

- Radio Lab

**Test Equipment**

1 Radiated Emissions

Lab to perform radiated emission tests

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---|---|---|---|---|---|---|
| 1.1 | NRV-Z1 | Sensor Head A | Rohde & Schwarz GmbH & Co. KG | 827753/005 | 2018-07 | 2019-07 |
| 1.2 | MFS | Rubidium Frequency Normal MFS | Datum GmbH | 002 | 2018-10 | 2020-10 |
| 1.3 | Opus10 TPR (8253.00) | ThermoAirpressure Datalogger 13 (Environ) | Lufft Mess- und Regeltechnik GmbH | 13936 | 2017-04 | 2019-04 |
| 1.4 | ESW44 | EMI Test Receiver | Rohde & Schwarz GmbH & Co. KG | 101603 | 2018-05 | 2019-05 |
| 1.5 | Anechoic Chamber | 10.58 x 6.38 x 6.00 m³ | Frankonia | none | 2018-06 | 2020-06 |
| 1.6 | FS-Z60 | Harmonic Mixer 40 - 60 GHz | Rohde & Schwarz Messgerätebau GmbH | 100178 | 2016-12 | 2019-12 |
| 1.7 | FS-Z220 | Harmonic Mixer 140 - 220 GHz | Rohde & Schwarz Messgerätebau GmbH | 101005 | 2017-03 | 2020-03 |
| 1.8 | SGH-05 | Standard Gain / Pyramidal Horn Antenna (140 - 220 GHz) | RPG-Radiometer Physics GmbH | 075 | | |
| 1.9 | HL 562 | Ultralog new biconicals | Rohde & Schwarz | 830547/003 | 2018-07 | 2021-07 |
| 1.10 | 5HC2700/12750-1.5-KK | High Pass Filter | Trilithic | 9942012 | | |
| 1.11 | ASP 1.2/1.8-10 kg | Antenna Mast | Maturo GmbH | - | | |
| 1.12 | 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 |
| 1.13 | Fluke 177 | Digital Multimeter 03 (Multimeter) | Fluke Europe B.V. | 86670383 | 2018-04 | 2020-04 |
| 1.14 | NRVD | Power Meter | Rohde & Schwarz GmbH & Co. KG | 828110/016 | 2018-07 | 2019-07 |
| 1.15 | HF 906 | Double-ridged horn | Rohde & Schwarz | 357357/002 | 2018-09 | 2021-09 |
| 1.16 | JS4-18002600-32-5P | Broadband Amplifier 18 GHz - 26 GHz | Miteq | 849785 | | |
| 1.17 | FSW 43 | Spectrum Analyzer | Rohde & Schwarz | 103779 | | |
| 1.18 | 3160-09 | Standard Gain / Pyramidal Horn Antenna 26.5 GHz | EMCO Elektronic GmbH | 00083069 | | |
| 1.19 | SGH-19 | Standard Gain / Pyramidal Horn Antenna (40 - 60 GHz) | RPG-Radiometer Physics GmbH | 093 | | |

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---|---|---|---|---|---|---|
| 1.20 | WHKX 7.0/18G-8SS | High Pass Filter | Wainwright | 09 | | |
| 1.21 | 4HC1600/12750-1.5-KK | High Pass Filter | Trilithic | 9942011 | | |
| 1.22 | Chroma 6404 | AC Power Source | Chroma ATE INC. | 64040001304 | | |
| 1.23 | JS4-00102600-42-5A | Broadband Amplifier 30 MHz - 26 GHz | Miteq | 619368 | | |
| 1.24 | TT 1.5 WI | Turn Table | Maturo GmbH | - | | |
| 1.25 | HL 562 Ultralog | Log.-per. Antenna | Rohde & Schwarz | 100609 | 2016-04 | 2019-04 |
| 1.26 | HF 906 | Double-ridged horn | Rohde & Schwarz | 357357/001 | 2018-03 | 2021-03 |
| 1.27 | FS-Z325 | Harmonic Mixer 220 - 325 GHz | Rohde & Schwarz Messgerätebau GmbH | 101006 | 2017-03 | 2020-03 |
| 1.28 | 3160-10 | Standard Gain / Pyramidal Horn Antenna 40 GHz | EMCO Elektronic GmbH | 00086675 | | |
| 1.29 | SGH-08 | Standard Gain / Pyramidal Horn Antenna (90 - 140 GHz) | RPG-Radiometer Physics GmbH | 064 | | |
| 1.30 | SGH-12 | Standard Gain / Pyramidal HornAntenna (60 - 90 GHz) | RPG-Radiometer Physics GmbH | 326 | | |
| 1.31 | 5HC3500/18000-1.2-KK | High Pass Filter | Trilithic | 200035008 | | |
| 1.32 | FS-Z140 | Harmonic Mixer 90 -140 GHz | Rohde & Schwarz Messgerätebau GmbH | 101007 | 2017-02 | 2020-02 |
| 1.33 | HFH2-Z2 | Loop Antenna | Rohde & Schwarz | 829324/006 | 2018-01 | 2021-01 |
| 1.34 | Opus10 THI (8152.00) | ThermoHygro Datalogger 12 (Environ) | Lufft Mess- und Regeltechnik GmbH | 12482 | 2017-03 | 2019-03 |
| 1.35 | ESR 7 | EMI Receiver / Spectrum Analyzer | Rohde & Schwarz | 101424 | 2019-01 | 2020-01 |
| 1.36 | JS4-00101800-35-5P | Broadband Amplifier 30 MHz - 18 GHz | Miteq | 896037 | | |
| 1.37 | AS 620 P | Antenna mast | HD GmbH | 620/37 | | |
| 1.38 | Tilt device Maturo (Rohacell) | Antrieb TD1.5-10kg | Maturo GmbH | TD1.5-10kg/024/3790709 | | |
| 1.39 | SGH-03 | Standard Gain / Pyramidal Horn Antenna (220 - 325 GHz) | RPG-Radiometer Physics GmbH | 060 | | |
| 1.40 | FS-Z90 | Harmonic Mixer 60 - 90 GHz | Rohde & Schwarz Messgerätebau GmbH | 101686 | 2017-03 | 2020-03 |

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---|---|---|---|---|---|---|
| 1.41 | ESIB 26 | Spectrum Analyzer | Rohde & Schwarz | 830482/004 | 2018-01 | 2020-01 |
| 1.42 | PAS 2.5 - 10 kg | Antenna Mast | Maturo GmbH | - | | |
| 1.43 | AFS42-00101800-25-S-42 | Broadband Amplifier 25 MHz - 18 GHz | Miteq | 2035324 | | |
| 1.44 | AM 4.0 | Antenna mast | Maturo GmbH | AM4.0/180/11920513 | | |
| 1.45 | HF 907 | Double-ridged horn | Rohde & Schwarz | 102444 | 2018-07 | 2021-07 |

2 Radio Lab
Conducted Radio Test Lab

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---|---|---|---|---|---|---|
| 2.1 | SMB100A | Signal Generator 9 kHz - 6 GHz | Rohde & Schwarz | 107695 | 2017-07 | 2020-07 |
| 2.2 | MFS | Rubidium Frequency Standard | Datum-Beverly | 5489/001 | 2018-07 | 2019-07 |
| 2.3 | FSV30 | Signal Analyzer 10 Hz - 30 GHz | Rohde & Schwarz | 103005 | 2018-04 | 2020-04 |
| 2.4 | Fluke 177 | Digital Multimeter 03 (Multimeter) | Fluke Europe B.V. | 86670383 | 2018-04 | 2020-04 |
| 2.5 | SMP03 | Signal Generator 2 GHz - 27 GHz | Rohde & Schwarz | 833680/003 | 2017-09 | 2020-09 |
| 2.6 | FSIQ26 | Signal Analyser | Rohde & Schwarz | 840061/005 | 2017-05 | 2019-05 |
| 2.7 | Chroma 6404 | AC Power Source | Chroma ATE INC. | 64040001304 | | |
| 2.8 | VT 4002 | Temperature Chamber | Vötsch | 58566002150010 | 2018-04 | 2020-04 |
| 2.9 | WA1515 | Broadband Power Divider SMA | Weinschel Associates | A855 | | |
| 2.10 | A8455-4 | 4 Way Power Divider (SMA) | | - | | |
| 2.11 | Opus10 THI (8152.00) | ThermoHygro Datalogger 03 (Environ) | Lufft Mess- und Regeltechnik GmbH | 7482 | 2017-03 | 2019-03 |
| 2.12 | SMBV100A | Vector Signal Generator 9 kHz - 6 GHz | Rohde & Schwarz | 259291 | 2016-10 | 2019-10 |

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 insertion loss ESH3-Z5 | cable loss (incl. 10 dB atten-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**

$U_{LISN}$ (dB µV) = U (dB µV) + 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 HFH-Z2) | Corr. | cable loss 1 (inside chamber) | cable loss 2 (outside chamber) | cable loss 3 (switch unit) | cable loss 4 (to receiver) | distance corr. (-40 dB/ decade) | $d_{Limit}$ (meas. distance (limit) | $d_{used}$ (meas. distance (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 (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (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 * LOG ($d_{Limit}$/ $d_{used}$)
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)

**($d_{Limit}$ = 3 m)**

| Frequency | AF R&S HL562 | Corr. | cable loss 1 (inside chamber) | cable loss 2 (outside chamber) | cable loss 3 (switch unit) | cable loss 4 (to receiver) | distance corr. (-20 dB/ decade) | $d_{Limit}$ (meas. distance (limit) | $d_{used}$ (meas. distance (used) |
|---|---|---|---|---|---|---|---|---|---|
| MHz | dB (1/m) | dB | dB | dB | dB | dB | dB | m | m |
| 30 | 18.6 | 0.6 | 0.29 | 0.04 | 0.23 | 0.02 | 0.0 | 3 | 3 |
| 50 | 6.0 | 0.9 | 0.39 | 0.09 | 0.32 | 0.08 | 0.0 | 3 | 3 |
| 100 | 9.7 | 1.2 | 0.56 | 0.14 | 0.47 | 0.08 | 0.0 | 3 | 3 |
| 150 | 7.9 | 1.6 | 0.73 | 0.20 | 0.59 | 0.12 | 0.0 | 3 | 3 |
| 200 | 7.6 | 1.9 | 0.84 | 0.21 | 0.70 | 0.11 | 0.0 | 3 | 3 |
| 250 | 9.5 | 2.1 | 0.98 | 0.24 | 0.80 | 0.13 | 0.0 | 3 | 3 |
| 300 | 11.0 | 2.3 | 1.04 | 0.26 | 0.89 | 0.15 | 0.0 | 3 | 3 |
| 350 | 12.4 | 2.6 | 1.18 | 0.31 | 0.96 | 0.13 | 0.0 | 3 | 3 |
| 400 | 13.6 | 2.9 | 1.28 | 0.35 | 1.03 | 0.19 | 0.0 | 3 | 3 |
| 450 | 14.7 | 3.1 | 1.39 | 0.38 | 1.11 | 0.22 | 0.0 | 3 | 3 |
| 500 | 15.6 | 3.2 | 1.44 | 0.39 | 1.20 | 0.19 | 0.0 | 3 | 3 |
| 550 | 16.3 | 3.5 | 1.55 | 0.46 | 1.24 | 0.23 | 0.0 | 3 | 3 |
| 600 | 17.2 | 3.5 | 1.59 | 0.43 | 1.29 | 0.23 | 0.0 | 3 | 3 |
| 650 | 18.1 | 3.6 | 1.67 | 0.34 | 1.35 | 0.22 | 0.0 | 3 | 3 |
| 700 | 18.5 | 3.6 | 1.67 | 0.42 | 1.41 | 0.15 | 0.0 | 3 | 3 |
| 750 | 19.1 | 4.1 | 1.87 | 0.54 | 1.46 | 0.25 | 0.0 | 3 | 3 |
| 800 | 19.6 | 4.1 | 1.90 | 0.46 | 1.51 | 0.25 | 0.0 | 3 | 3 |
| 850 | 20.1 | 4.4 | 1.99 | 0.60 | 1.56 | 0.27 | 0.0 | 3 | 3 |
| 900 | 20.8 | 4.7 | 2.14 | 0.60 | 1.63 | 0.29 | 0.0 | 3 | 3 |
| 950 | 21.1 | 4.8 | 2.22 | 0.60 | 1.66 | 0.33 | 0.0 | 3 | 3 |
| 1000 | 21.6 | 4.9 | 2.23 | 0.61 | 1.71 | 0.30 | 0.0 | 3 | 3 |

**($d_{Limit}$ = 10 m)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 30 | 18.6 | -9.9 | 0.29 | 0.04 | 0.23 | 0.02 | -10.5 | 10 | 3 |
| 50 | 6.0 | -9.6 | 0.39 | 0.09 | 0.32 | 0.08 | -10.5 | 10 | 3 |
| 100 | 9.7 | -9.2 | 0.56 | 0.14 | 0.47 | 0.08 | -10.5 | 10 | 3 |
| 150 | 7.9 | -8.8 | 0.73 | 0.20 | 0.59 | 0.12 | -10.5 | 10 | 3 |
| 200 | 7.6 | -8.6 | 0.84 | 0.21 | 0.70 | 0.11 | -10.5 | 10 | 3 |
| 250 | 9.5 | -8.3 | 0.98 | 0.24 | 0.80 | 0.13 | -10.5 | 10 | 3 |
| 300 | 11.0 | -8.1 | 1.04 | 0.26 | 0.89 | 0.15 | -10.5 | 10 | 3 |
| 350 | 12.4 | -7.9 | 1.18 | 0.31 | 0.96 | 0.13 | -10.5 | 10 | 3 |
| 400 | 13.6 | -7.6 | 1.28 | 0.35 | 1.03 | 0.19 | -10.5 | 10 | 3 |
| 450 | 14.7 | -7.4 | 1.39 | 0.38 | 1.11 | 0.22 | -10.5 | 10 | 3 |
| 500 | 15.6 | -7.2 | 1.44 | 0.39 | 1.20 | 0.19 | -10.5 | 10 | 3 |
| 550 | 16.3 | -7.0 | 1.55 | 0.46 | 1.24 | 0.23 | -10.5 | 10 | 3 |
| 600 | 17.2 | -6.9 | 1.59 | 0.43 | 1.29 | 0.23 | -10.5 | 10 | 3 |
| 650 | 18.1 | -6.9 | 1.67 | 0.34 | 1.35 | 0.22 | -10.5 | 10 | 3 |
| 700 | 18.5 | -6.8 | 1.67 | 0.42 | 1.41 | 0.15 | -10.5 | 10 | 3 |
| 750 | 19.1 | -6.3 | 1.87 | 0.54 | 1.46 | 0.25 | -10.5 | 10 | 3 |
| 800 | 19.6 | -6.3 | 1.90 | 0.46 | 1.51 | 0.25 | -10.5 | 10 | 3 |
| 850 | 20.1 | -6.0 | 1.99 | 0.60 | 1.56 | 0.27 | -10.5 | 10 | 3 |
| 900 | 20.8 | -5.8 | 2.14 | 0.60 | 1.63 | 0.29 | -10.5 | 10 | 3 |
| 950 | 21.1 | -5.6 | 2.22 | 0.60 | 1.66 | 0.33 | -10.5 | 10 | 3 |
| 1000 | 21.6 | -5.6 | 2.23 | 0.61 | 1.71 | 0.30 | -10.5 | 10 | 3 |

**Sample calculation**

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (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 = -20 * LOG ($d_{Limit}$/ $d_{used}$)
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 R&S HF907 | Corr. | cable loss 1 (relay + cable inside chamber) | cable loss 2 (outside chamber) | cable loss 3 (switch unit, atten-uator & pre-amp) | cable loss 4 (to receiver) | | |
|---|---|---|---|---|---|---|---|---|
| MHz | dB (1/m) | dB | dB | dB | dB | dB | | |
| 1000 | 24.4 | -19.4 | 0.99 | 0.31 | -21.51 | 0.79 | | |
| 2000 | 28.5 | -17.4 | 1.44 | 0.44 | -20.63 | 1.38 | | |
| 3000 | 31.0 | -16.1 | 1.87 | 0.53 | -19.85 | 1.33 | | |
| 4000 | 33.1 | -14.7 | 2.41 | 0.67 | -19.13 | 1.31 | | |
| 5000 | 34.4 | -13.7 | 2.78 | 0.86 | -18.71 | 1.40 | | |
| 6000 | 34.7 | -12.7 | 2.74 | 0.90 | -17.83 | 1.47 | | |
| 7000 | 35.6 | -11.0 | 2.82 | 0.86 | -16.19 | 1.46 | | |

| Frequency | AF R&S HF907 | Corr. | cable loss 1 (relay inside chamber) | cable loss 2 (inside chamber) | cable loss 3 (outside chamber) | cable loss 4 (switch unit, atten-uator & pre-amp) | cable loss 5 (to receiver) | used for FCC 15.247 |
|---|---|---|---|---|---|---|---|---|
| MHz | dB (1/m) | dB | dB | dB | dB | dB | dB | |
| 3000 | 31.0 | -23.4 | 0.47 | 1.87 | 0.53 | -27.58 | 1.33 | |
| 4000 | 33.1 | -23.3 | 0.56 | 2.41 | 0.67 | -28.23 | 1.31 | |
| 5000 | 34.4 | -21.7 | 0.61 | 2.78 | 0.86 | -27.35 | 1.40 | |
| 6000 | 34.7 | -21.2 | 0.58 | 2.74 | 0.90 | -26.89 | 1.47 | |
| 7000 | 35.6 | -19.8 | 0.66 | 2.82 | 0.86 | -25.58 | 1.46 | |

| Frequency | AF R&S HF907 | Corr. | cable loss 1 (relay inside chamber) | cable loss 2 (High Pass) | cable loss 3 (pre-amp) | cable loss 4 (inside chamber) | cable loss 5 (outside chamber) | cable loss 6 (to receiver) |
|---|---|---|---|---|---|---|---|---|
| MHz | dB (1/m) | dB | dB | dB | dB | dB | dB | dB |
| 7000 | 35.6 | -57.3 | 0.56 | 1.28 | -62.72 | 2.66 | 0.94 | 1.46 |
| 8000 | 36.3 | -56.3 | 0.69 | 0.71 | -61.49 | 2.84 | 1.00 | 1.53 |
| 9000 | 37.1 | -55.3 | 0.68 | 0.65 | -60.80 | 3.06 | 1.09 | 1.60 |
| 10000 | 37.5 | -56.2 | 0.70 | 0.54 | -61.91 | 3.28 | 1.20 | 1.67 |
| 11000 | 37.5 | -55.3 | 0.80 | 0.61 | -61.40 | 3.43 | 1.27 | 1.70 |
| 12000 | 37.6 | -53.7 | 0.84 | 0.42 | -59.70 | 3.53 | 1.26 | 1.73 |
| 13000 | 38.2 | -53.5 | 0.83 | 0.44 | -59.81 | 3.75 | 1.32 | 1.83 |
| 14000 | 39.9 | -56.3 | 0.91 | 0.53 | -63.03 | 3.91 | 1.40 | 1.77 |
| 15000 | 40.9 | -54.1 | 0.98 | 0.54 | -61.05 | 4.02 | 1.44 | 1.83 |
| 16000 | 41.3 | -54.1 | 1.23 | 0.49 | -61.51 | 4.17 | 1.51 | 1.85 |
| 17000 | 42.8 | -54.4 | 1.36 | 0.76 | -62.36 | 4.34 | 1.53 | 2.00 |
| 18000 | 44.2 | -54.7 | 1.70 | 0.53 | -62.88 | 4.41 | 1.55 | 1.91 |

**Sample calculation**

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (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 EMCO 3160-09 | Corr. | cable loss 1 (inside chamber) | cable loss 2 (pre-amp) | cable loss 3 (inside chamber) | cable loss 4 (switch unit) | cable loss 5 (to 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 (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (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 EMCO 3160-10 | Corr. | cable loss 1 (inside chamber) | cable loss 2 (outside chamber) | cable loss 3 (switch unit) | cable loss 4 (to receiver) | distance corr. (-20 dB/ decade) | $d_{Limit}$ (meas. distance (limit) | $d_{used}$ (meas. distance (used) |
|---|---|---|---|---|---|---|---|---|---|
| GHz | dB (1/m) | dB | dB | dB | dB | dB | dB | m | m |
| 26.5 | 43.4 | -11.2 | 4.4 | | | | -9.5 | 3 | 1.0 |
| 27.0 | 43.4 | -11.2 | 4.4 | | | | -9.5 | 3 | 1.0 |
| 28.0 | 43.4 | -11.1 | 4.5 | | | | -9.5 | 3 | 1.0 |
| 29.0 | 43.5 | -11.0 | 4.6 | | | | -9.5 | 3 | 1.0 |
| 30.0 | 43.5 | -10.9 | 4.7 | | | | -9.5 | 3 | 1.0 |
| 31.0 | 43.5 | -10.8 | 4.7 | | | | -9.5 | 3 | 1.0 |
| 32.0 | 43.5 | -10.7 | 4.8 | | | | -9.5 | 3 | 1.0 |
| 33.0 | 43.6 | -10.7 | 4.9 | | | | -9.5 | 3 | 1.0 |
| 34.0 | 43.6 | -10.6 | 5.0 | | | | -9.5 | 3 | 1.0 |
| 35.0 | 43.6 | -10.5 | 5.1 | | | | -9.5 | 3 | 1.0 |
| 36.0 | 43.6 | -10.4 | 5.1 | | | | -9.5 | 3 | 1.0 |
| 37.0 | 43.7 | -10.3 | 5.2 | | | | -9.5 | 3 | 1.0 |
| 38.0 | 43.7 | -10.2 | 5.3 | | | | -9.5 | 3 | 1.0 |
| 39.0 | 43.7 | -10.2 | 5.4 | | | | -9.5 | 3 | 1.0 |
| 40.0 | 43.8 | -10.1 | 5.5 | | | | -9.5 | 3 | 1.0 |

**Sample calculation**

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (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 * LOG ($d_{Limit}$/ $d_{used}$)
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values.

# 7 SETUP DRAWINGS

# 8 MEASUREMENT UNCERTAINTIES

| Test Case(s) | Parameter | Uncertainty |
|---|---|---|
| - Field strength of spurious radiation | Field Strength | ± 5.5 dB |
| - Emission and Occupied Bandwidth | Power<br>Frequency | ± 2.9 dB<br>± 11.2 kHz |
| - RF Output Power<br>- Peak to Average Ratio | Power | ± 2.2 dB |
| - Band Edge Compliance<br>- Spurious Emissions at Antenna Terminal | Power<br>Frequency | ± 2.2 dB<br>± 11.2 kHz |
| - Frequency Stability | Frequency | ± 25 Hz |

# 9 PHOTO REPORT

Please see separate photo report.