

ISED CABid: ES1909

Test Report No:  
 NIE: 71232RRF.001

# Test Report

## USA FCC Part 22

## CANADA RSS-132

|   |   |
|---|---|
| (*) Identification of item tested         | LTE Cat-M Cellular communication module in SiP packaging  |
| (*) Trademark                             | Sequans Communications  |
| (*) Model and /or type reference          | SKY66431  |
| Other identification of the product       | FCC ID: 2AAGM66431<br>IC: 12732A-66431  |
| (*) Features                              | LTE-M, 3GPP LTE Release 14<br>HW Version: V1<br>SW Version: LR8.0.6.1-56267   |
| Applicant                                 | SEQUANS COMMUNICATIONS<br>55 Boulevard Charles de Gaulle, 92700 Colombes, France  |
| Test method requested, standard           | USA FCC Part 22 (10-1-21 Edition).<br>CANADA RSS-132 Issue 3, Jan. 2013.<br>ANSI C63.26-2015.<br>KDB 971168 D01 Power Meas License Digital Systems v03r01, April. 2018. |
| Summary                                   | IN COMPLIANCE   |
| Approved by (name / position & signature) | Rafael López Martín<br>EMC Consumer & RF Lab. Manager   |
| Date of issue                             | 2022-10-25  |
| Report template No.                       | FDT08_24<br>(* "Data provided by the client")   |

## Index

|   |    |
|---|----|
| Competences and guarantees .....                        | 3  |
| General conditions .....                                | 3  |
| Uncertainty.....  | 3  |
| Data provided by the client .....                       | 3  |
| Usage of samples .....                                  | 4  |
| Test sample description .....                           | 5  |
| Identification of the client .....                      | 6  |
| Testing period and place .....                          | 6  |
| Document history.....                                   | 6  |
| Environmental conditions .....                          | 7  |
| Remarks and comments.....                               | 8  |
| Testing verdicts.....                                   | 8  |
| Summary .....   | 9  |
| Appendix A: Test results for FCC Part 22 / RSS-132..... | 10 |

## Competences and guarantees

---

DEKRA Testing and Certification is a testing laboratory accredited by the National Accreditation Body (ENAC - Entidad Nacional de Acreditación) to perform the tests indicated in the Certificate No. 51/LE 147.

DEKRA Testing and Certification is an FCC-recognized accredited testing laboratory with appropriate scope of accreditation that covers the performed tests in this report.

DEKRA Testing and Certification is an ISED-recognized accredited testing laboratory, CABid: ES1909, with the appropriate scope of accreditation that covers the performed tests in this report.

In order to assure the traceability to other national and international laboratories, DEKRA Testing and Certification has a calibration and maintenance program for its measurement equipment.

DEKRA Testing and Certification guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and it is based on the knowledge and technical facilities available at DEKRA Testing and Certification at the time of performance of the test.

DEKRA Testing and Certification is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

The results presented in this Test Report apply only to the particular item under test established in this document.

**IMPORTANT:** No parts of this report may be reproduced or quoted out of context, in any form or by any means, except in full, without the previous written permission of DEKRA Testing and Certification.

## General conditions

---

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
3. This document is only valid if complete; no partial reproduction can be made without previous written permission of DEKRA Testing and Certification S.A.U.
4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of DEKRA Testing and Certification S.A.U. and the Accreditation Bodies.

## Uncertainty

---

Uncertainty (factor  $k=2$ ) was calculated according to the DEKRA Testing and Certification S.A.U. internal document PODT000.

## Data provided by the client

---

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested").
2. The sample model SKY66431 is a Most compact LTE modem and RF front-end in a single package:
  - Same chipset as GM02S module i.e. SQN3430.
  - Integrated baseband, transceiver, RF front end, RAM memory, crystals and power management.
  - 8.8 x 11.3 x 1.585 (max.) mm BGA package, 0.5 and 1 mm pitch.
  - Compliant to 3GPP Rel-14, upgradeable to 3GPP Rel-15 & 16.
  - Optimized for half-duplex operation (HD-FDD) for LTE-M.

DEKRA Testing and Certification S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

## Usage of samples

Samples undergoing test have been selected by: The client.

- Sample S/01 is composed of the following elements:

| Control No. | Description  | Model    | Serial No. | Date of reception |
|-------------|--|----------|------------|-------------------|
| 71232B/004  | LTE Cat-M Cellular communication module in SiP packaging | SKY66431 | 171        | 2022/07/14        |

Auxiliary elements used with the Sample S/01:

| Control No. | Description | Model | Serial No. | Date of reception |
|-------------|-------------|-------|------------|-------------------|
| 71605/014   | SMA Cable   | --    | --         | 2022/04/04        |
| 71605/019   | USB Cable   | --    | --         | 2022/04/04        |

Sample S/01 has undergone the following test(s): The Conducted tests indicated in Appendix A.

- Sample S/02 is composed of the following elements:

| Control No. | Description  | Model    | Serial No. | Date of reception |
|-------------|--|----------|------------|-------------------|
| 71232B/004  | LTE Cat-M Cellular communication module in SiP packaging | SKY66431 | 171        | 2022/07/14        |

Auxiliary elements used with the Sample S/02:

| Control No. | Description | Model | Serial No. | Date of reception |
|-------------|-------------|-------|------------|-------------------|
| 71605/019   | USB Cable   | --    | --         | 2022/04/04        |

Sample S/02 has undergone the following test(s): The Radiated tests indicated in Appendix A.

## Test sample description

|   |                                     |                                |                                     |                          |                                   |                          |                          |
|---|-------------------------------------|--------------------------------|-------------------------------------|--------------------------|-----------------------------------|--------------------------|--------------------------|
| Ports.....:                                   | Port name and description           | Cable                          |                                     |                          |                                   |                          |                          |
|   |                                     | Specified max length [m]       | Attached during test                | Shielded                 | Coupled to patient <sup>(3)</sup> |                          |                          |
|   | USB                                 | 2                              | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>          |                          |                          |
|   | -                                   |                                | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>          |                          |                          |
| Supplementary information to the ports.....:  | -                                   |                                |                                     |                          |                                   |                          |                          |
| Rated power supply .....                      | Voltage and Frequency               |                                | Reference poles                     |                          |                                   |                          |                          |
|   |                                     |                                | L1                                  | L2                       | L3                                | N                        | PE                       |
|   | <input type="checkbox"/>            | AC:                            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>          | <input type="checkbox"/> | <input type="checkbox"/> |
| <input checked="" type="checkbox"/>           | DC: 3.3V USB port                   |                                |                                     |                          |                                   |                          |                          |
| Rated Power.....:                             | -                                   |                                |                                     |                          |                                   |                          |                          |
| Clock frequencies.....:                       | -                                   |                                |                                     |                          |                                   |                          |                          |
| Other parameters .....                        | -                                   |                                |                                     |                          |                                   |                          |                          |
| Software version.....:                        | LR8.0.6.1-56267                     |                                |                                     |                          |                                   |                          |                          |
| Hardware version .....                        | V1                                  |                                |                                     |                          |                                   |                          |                          |
| Dimensions in cm (W x H x D) ...:             | -                                   |                                |                                     |                          |                                   |                          |                          |
| Mounting position .....                       | <input checked="" type="checkbox"/> | Table top equipment            |                                     |                          |                                   |                          |                          |
|   | <input type="checkbox"/>            | Wall/Ceiling mounted equipment |                                     |                          |                                   |                          |                          |
|   | <input type="checkbox"/>            | Floor standing equipment       |                                     |                          |                                   |                          |                          |
|   | <input type="checkbox"/>            | Hand-held equipment            |                                     |                          |                                   |                          |                          |
|   | <input type="checkbox"/>            | Other:                         |                                     |                          |                                   |                          |                          |
| Modules/parts.....:                           | Module/parts of test item           |                                | Type                                | Manufacturer             |                                   |                          |                          |
|   | NEKTAR-EVK                          |                                |                                     |                          |                                   |                          |                          |
|   | USB Cable                           |                                |                                     |                          |                                   |                          |                          |
|   | External antenna                    |                                |                                     |                          |                                   |                          |                          |
|   | -                                   |                                |                                     |                          |                                   |                          |                          |
| Accessories (not part of the test item) ..... | Description                         |                                | Type                                | Manufacturer             |                                   |                          |                          |
|   | -                                   |                                |                                     |                          |                                   |                          |                          |
|   | -                                   |                                |                                     |                          |                                   |                          |                          |
| Documents as provided by the applicant .....  | Description                         |                                | File name                           | Issue date               |                                   |                          |                          |
|   | -                                   |                                |                                     |                          |                                   |                          |                          |
|   | -                                   |                                |                                     |                          |                                   |                          |                          |

(3) Only for Medical Equipment

## Identification of the client

---

SEQUANS COMMUNICATIONS

55 Boulevard Charles de Gaulle, 92700 Colombes, France

## Testing period and place

---

|                      |  |
|----------------------|--|
| <b>Test Location</b> | DEKRA Testing and Certification S.A.U. |
| <b>Date (start)</b>  | 2022-07-25                             |
| <b>Date (finish)</b> | 2022-09-15                             |

## Document history

---

| Report number | Date       | Description    |
|---------------|------------|----------------|
| 71232RRF.001  | 2022-10-25 | First release. |

## Environmental conditions

---

In the control chamber, the following limits were not exceeded during the test:

|                          |                              |
|--------------------------|------------------------------|
| <b>Temperature</b>       | Min. = 15 °C<br>Max. = 35 °C |
| <b>Relative humidity</b> | Min. = 20 %<br>Max. = 75 %   |

In the semi-anechoic chamber, the following limits were not exceeded during the test:

|                          |                              |
|--------------------------|------------------------------|
| <b>Temperature</b>       | Min. = 15 °C<br>Max. = 35 °C |
| <b>Relative humidity</b> | Min. = 20 %<br>Max. = 75 %   |

In the chamber for conducted measurements, the following limits were not exceeded during the test:

|                          |                              |
|--------------------------|------------------------------|
| <b>Temperature</b>       | Min. = 15 °C<br>Max. = 35 °C |
| <b>Relative humidity</b> | Min. = 20 %<br>Max. = 75 %   |

## Remarks and comments

The tests have been performed by the technical personnel: Miguel Manuel López and Nicolás Salguero

Used instrumentation:

### Conducted Measurements

|   | Last Calibration | Due Calibration |
|---|------------------|-----------------|
| 1. Shielded Room ETS LINDGREN S101                              | N/A              | N/A             |
| 2. Wideband Radio Communication Tester ROHDE AND SCHWARZ CMW500 | 2021/09          | 2023/09         |
| 3. Signal Analyzer 20 Hz to 8 GHz ROHDE AND SCHWARZ FSQ8        | 2020/10          | 2022/10         |
| 4. Spectrum analyser Rohde & Schwarz FSV40                      | 2021/10          | 2023/10         |
| 5. Climatic chamber HERAEUS VMT 04/35                           | 2022/07          | 2024/07         |
| 6. DC Power Supply Keysight Technologies U8002A                 | N/A              | N/A             |
| 7. Digital multimeter FLUKE 179                                 | 2021/11          | 2022/11         |

### Radiated Measurements

|   | Last Calibration | Due Calibration |
|---|------------------|-----------------|
| 1. Semianechoic Absorber Lined Chamber ETS LINDGREN FACT 3 200 STP      | N/A              | N/A             |
| 2. Shielded Room ETS LINDGREN S101                                      | N/A              | N/A             |
| 3. Biconical/Log Antenna 30 MHz - 6 GHz ETS LINDGREN 3142E              | 2020/04          | 2023/04         |
| 4. Horn Antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D        | 2019/11          | 2022/11         |
| 5. RF Preamplifier, 40 dB ,1-18 GHz BONN ELEKTRONIK BLMA 0118-1M        | 2022/07          | 2023/07         |
| 6. HORN ANTENNA 18-40GHz SCHWARZBECK BBHA 9170                          | 2020/05          | 2023/05         |
| 7. PRE-AMPLIFIER G>30dB 17-40GHz BONN ELEKTRONIK BLMA 1840-4A           | 09/2021          | 09/2022         |
| 8.. Signal and Spectrum Analyzer 10 Hz - 40 GHz ROHDE AND SCHWARZ FSV40 | 2022/05          | 2024/05         |
| 9. EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7                       | 2021/11          | 2023/11         |
| 10. Wideband Radio Communication Tester ROHDE AND SCHWARZ CMW500        | N/A              | N/A             |
| 11. EMC/RF Test SW ROHDE AND SCHWARZ EMC32                              | N/A              | N/A             |



## Testing verdicts

|                 |     |
|-----------------|-----|
| Not applicable: | N/A |
| Pass:           | P   |
| Fail:           | F   |
| Not measured:   | N/M |

## Summary

### LTE Cat M1 Band 5:

| FCC PART 22 / RSS-132   |         |        |
|---|---------|--------|
| Requirement – Test case   | Verdict | Remark |
| Clause 22.913 / RSS-132 Clause 5.4: RF output power                         | P       |        |
| Clause 2.1047 / RSS-132 Clause 5.2: Modulation characteristics              | P       |        |
| Clause 22.355 / RSS-132 Clause 5.3: Frequency stability                     | P       |        |
| Clause 2.1049: Occupied Bandwidth   | P       |        |
| Clause 22.917 / RSS-132 Clause 5.5: Spurious emissions at antenna terminals | P       |        |
| Clause 22.917 / RSS-132 Clause 5.5: Radiated emissions                      | P       |        |
| <u>Supplementary information and remarks:</u>                               |         |        |
| None.   |         |        |

## Appendix A: Test results for FCC Part 22 / RSS-132

## INDEX

|   |    |
|---|----|
| TEST CONDITIONS .....                                       | 12 |
| RF Output Power .....                                       | 12 |
| Frequency Stability .....                                   | 17 |
| Modulation Characteristics .....                            | 22 |
| Occupied Bandwidth .....                                    | 23 |
| Spurious emissions at antenna terminals.....                | 30 |
| Spurious emissions at antenna terminals at Block Edges..... | 34 |
| Radiated emissions .....                                    | 36 |

## TEST CONDITIONS

(\*): Data provided by the applicant.

### POWER SUPPLY (\*):

Vnormal: 3.3 Vdc (\*)

Vminimum: 2.805 Vdc

Vmaximum: 3.795 Vdc

Type of Power Supply: USB.

### ANTENNA (\*):

Device with external and internal antennas.

After a preliminary scan, the determined worst case for the Radiated tests is the internal antenna.

For the Conducted tests, the highest antenna gain was used: internal antenna gain.

Declared Gain for antennas:

| Low Bands  | GAIN (dBi) | ANTENNA TYPE     |
|------------|------------|------------------|
| LTE Band 5 | +1.1       | Internal Antenna |
|            | +0.17      | External Antenna |

### TEST FREQUENCIES:

LTE Band 5. QPSK AND 16QAM MODULATIONS:

|        | Channel per Nominal Bandwidth (Frequency, MHz) |                   |                   |                   |
|--------|--|-------------------|-------------------|-------------------|
|        | BW = 1.4 MHz<br>(*)                            | BW = 3 MHz<br>(*) | BW = 5 MHz        | BW = 10 MHz       |
| Low    | 20407<br>(824.70)                              | 20415<br>(825.50) | 20425<br>(826.50) | 20450<br>(829.00) |
| Middle | 20525<br>(836.50)                              | 20525<br>(836.50) | 20525<br>(836.50) | 20525<br>(836.50) |
| High   | 20643<br>(848.30)                              | 20635<br>(847.50) | 20625<br>(846.50) | 20600<br>(844.00) |

(\*) The EUT does not support the Nominal Bandwidths 1.4 MHz, 3 MHz.

## RF Output Power

### SPECIFICATION:

FCC §2.1046 and FCC §22.913. The Effective Radiated Power (E.R.P.) of mobile transmitter and auxiliary test transmitter must not exceed 7 Watts (38.45 dBm E.R.P.).

RSS-132. Clause 5.4. The equivalent isotropically radiated power (e.i.r.p.) for mobile equipment shall not exceed 11.5 watts (38.45 dBm E.R.P.).

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 High PAPR during periods of continuous transmission.

### METHOD:

The conducted RF output power measurements were made at the RF output terminals of the EUT using the power meter of the Universal Radio Communication tester R&S CMW500, selecting maximum transmission power of the EUT and different modes of modulation.

The maximum equivalent isotropically radiated power (e.i.r.p.) is calculated by adding the declared maximum antenna gain (dBi).

The maximum effective radiated power e.r.p. is calculated from the maximum equivalent isotropically radiated power (e.i.r.p.) by subtracting 2.15 dB:

$$E.R.P. = E.I.R.P. - 2.15 \text{ dB}$$

The peak-to-average power ratio (PAPR) is measured using an attenuator, power splitter and spectrum analyser with a Complementary Cumulative Distribution Function implemented.

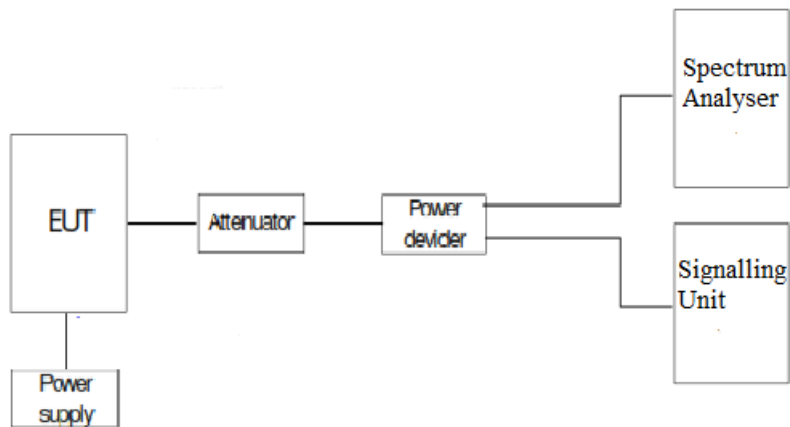
The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

## TEST SETUP

### 1. CONDUCTED AVERAGE POWER:



### 2. PEAK-TO-AVERAGE POWER RATIO (PAPR):



**RESULTS:**

**LTE Band 5:**

**1. CONDUCTED AVERAGE POWER:**

LTE Band 5. QPSK MODULATION. Bandwidth = 5 MHz.

| Channel  | Low    | Middle | High  |
|--|--------|--------|-------|
| Maximum declared antenna gain (dBi)                              | 1.1    |        |       |
| Measured maximum average power (dBm) at antenna port             | 23.44  | 23.26  | 23.36 |
| Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm) | 24.54  | 24.36  | 24.46 |
| Maximum effective radiated power E.R.P. (dBm)                    | 22.39  | 22.21  | 22.31 |
| PAPR (dB)  | (*)    |        |       |
| Measurement uncertainty (dB)                                     | <±0.66 |        |       |

Average Power Worst Case: Modulation QPSK. RB Size: 1. RB Offset: 0. Narrowband: 0.

(\*): Preliminary measurements determined 16QAM as the worst-case modulation in terms of PAPR.

LTE Band 5. 16QAM MODULATION. Bandwidth = 5 MHz.

| Channel  | Low    | Middle | High  |
|--|--------|--------|-------|
| Maximum declared antenna gain (dBi)                              | 1.1    |        |       |
| Measured maximum average power (dBm) at antenna port             | 23.10  | 23.08  | 22.99 |
| Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm) | 24.20  | 24.18  | 24.09 |
| Maximum effective radiated power E.R.P. (dBm)                    | 22.05  | 22.03  | 21.94 |
| PAPR (dB)  | 6.30   | 6.81   | 5.88  |
| Measurement uncertainty (dB)                                     | <±0.66 |        |       |

Average Power Worst Case: Modulation 16QAM. RB Size: 1. RB Offset: 0. Narrowband: 0.

PAPR Worst Case: Modulation 16QAM. RB Size: 5. RB Offset: 0. Narrowband: 0.

LTE Band 5. QPSK MODULATION. Bandwidth = 10 MHz.

| Channel  | Low    | Middle | High  |
|--|--------|--------|-------|
| Maximum declared antenna gain (dBi)                              | 1.1    |        |       |
| Measured maximum average power (dBm) at antenna port             | 23.43  | 23.22  | 23.33 |
| Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm) | 24.53  | 24.32  | 24.43 |
| Maximum effective radiated power E.R.P. (dBm)                    | 22.38  | 22.17  | 22.28 |
| PAPR (dB)  | (*)    |        |       |
| Measurement uncertainty (dB)                                     | <±0.66 |        |       |

Average Power Worst Case: Modulation QPSK. RB Size: 1. RB Offset: 0. Narrowband: 0.

(\*): Preliminary measurements determined 16QAM as the worst-case modulation in terms of PAPR.

LTE Band 5. 16QAM MODULATION. Bandwidth = 10 MHz.

| Channel  | Low    | Middle | High  |
|--|--------|--------|-------|
| Maximum declared antenna gain (dBi)                              | 1.1    |        |       |
| Measured maximum average power (dBm) at antenna port             | 23.18  | 23.09  | 23.02 |
| Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm) | 24.28  | 24.19  | 24.12 |
| Maximum effective radiated power E.R.P. (dBm)                    | 22.13  | 22.04  | 21.97 |
| PAPR (dB)  | 6.49   | 6.49   | 5.21  |
| Measurement uncertainty (dB)                                     | <±0.66 |        |       |

Average Power Worst Case: Modulation 16QAM. RB Size: 1. RB Offset: 0. Narrowband: 0.

PAPR Worst Case: Modulation 16QAM. RB Size: 5. RB Offset: 0. Narrowband: 0.

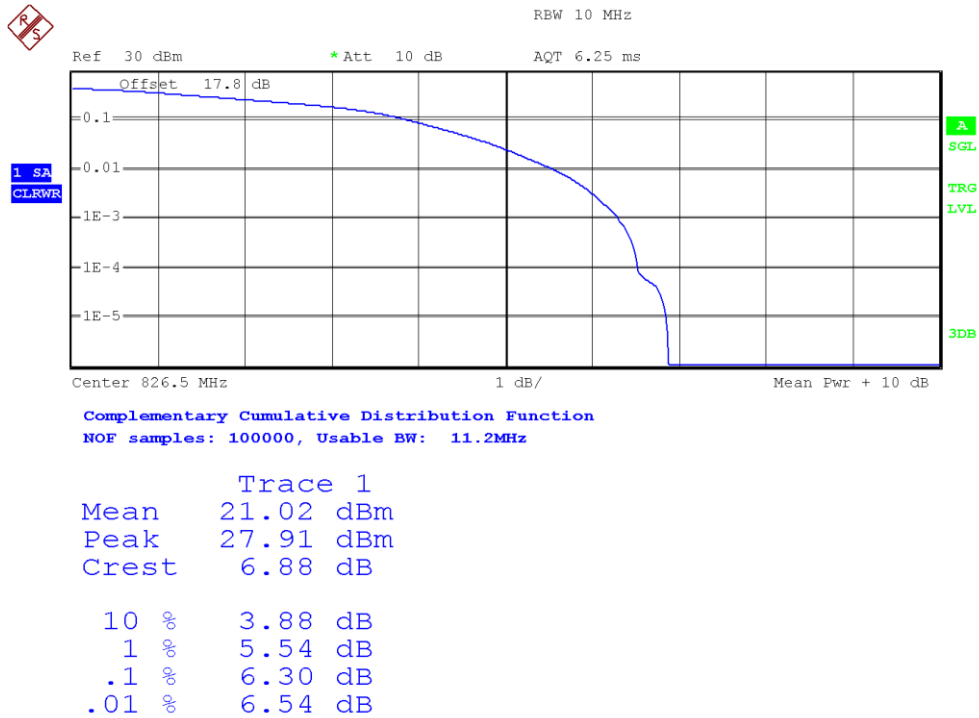


## 2. PEAK-TO-AVERAGE POWER RATIO (PAPR):

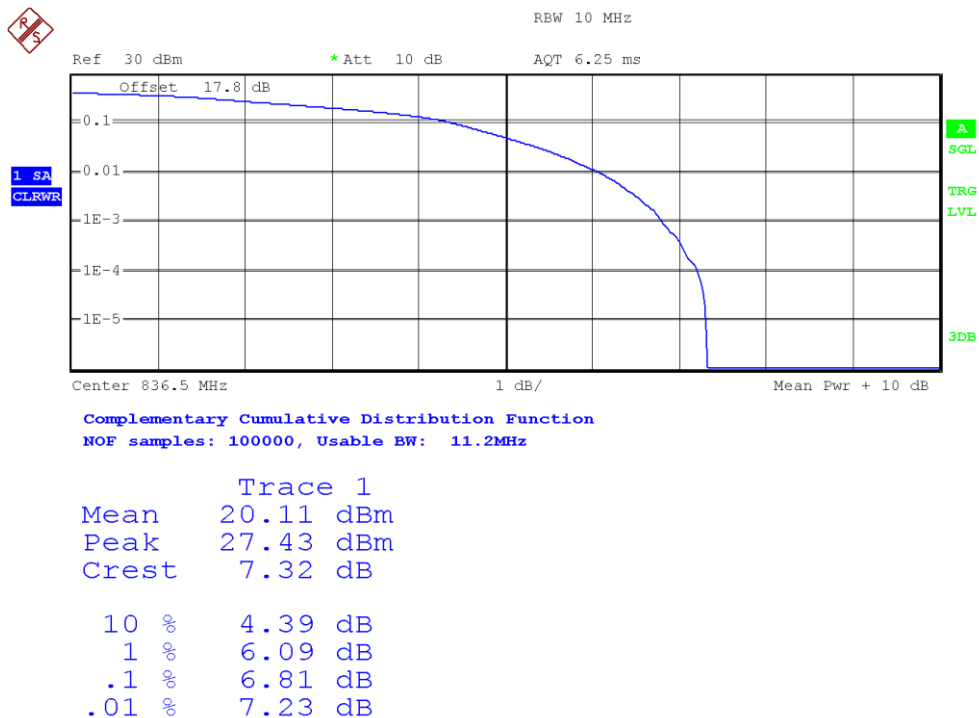
The next results are for the worst-case configuration.

LTE Band 5. Bandwidth = 5 MHz. Modulation 16 QAM. RB Size: 5. RB Offset: 0. Narrowband: 0.

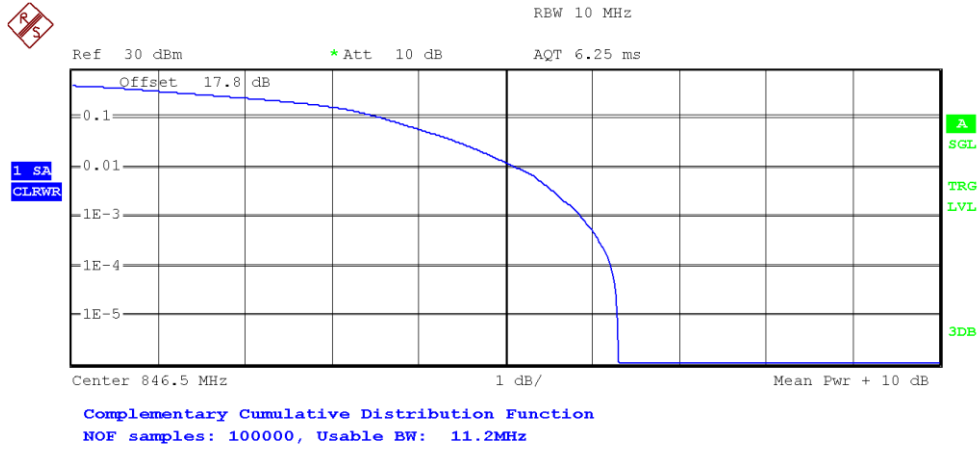
Low Channel:



Middle Channel:



High Channel:



| Trace 1 |           |
|---------|-----------|
| Mean    | 21.01 dBm |
| Peak    | 27.31 dBm |
| Crest   | 6.30 dB   |
| 10 %    | 3.59 dB   |
| 1 %     | 5.13 dB   |
| .1 %    | 5.88 dB   |
| .01 %   | 6.22 dB   |

| Channel                      | Measured maximum average power (dBm) at antenna port | Maximum declared antenna gain (dBi) | Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm) | Maximum effective radiated power E.R.P. (dBm) | PAPR (dB) |
|------------------------------|--|-------------------------------------|--|---|-----------|
| Low                          | 23.44  | 1.10                                | 24.54  | 22.39   | 6.49      |
| Middle                       | 23.26  |                                     | 24.36  | 22.21   | 6.81      |
| High                         | 23.36  |                                     | 24.46  | 22.31   | 5.88      |
| Measurement uncertainty (dB) | <±0.66   |                                     |  |   |           |

Verdict: PASS

## Frequency Stability

### SPECIFICATION:

FCC §2.1055 and §22.355.  $\pm 2.5$  ppm for mobile stations operating in the range 821 to 896 MHz.

RSS-132. Clause 5.3. The carrier frequency shall not depart from the reference frequency in excess of  $\pm 2.5$  ppm for mobile stations.

### METHOD:

The frequency tolerance measurements over temperature variations were made over the temperature range of  $-30^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$ . The EUT was placed inside a climatic chamber and the temperature was raised hourly in  $10^{\circ}\text{C}$  steps from  $-30^{\circ}\text{C}$  up to  $+50^{\circ}\text{C}$ .

The supply voltage was varied between 85% and 115% of nominal voltage.

The EUT was set in "Radio Resource Control (RRC) mode" on the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.

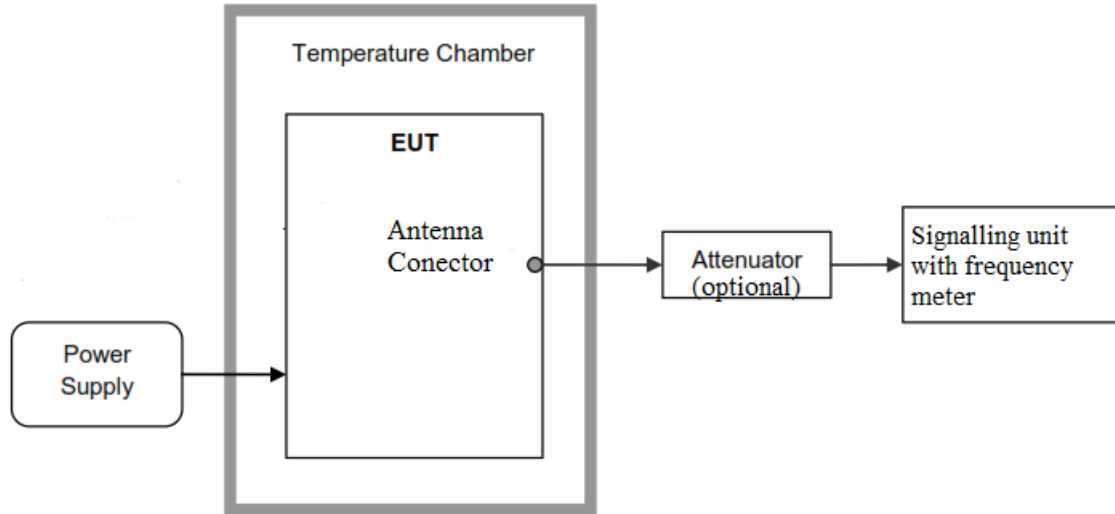
The worst-case LTE mode for conducted power was used for the test.

In order to check that the frequency stability is sufficient such that the fundamental emissions stay within the authorized bands of operation, a reference point is established at the applicable unwanted emissions limit using a RBW equal to the RBW required by the unwanted emissions specification of the applicable regulatory standard. These reference points measured using the lowest and highest channels of operation are identified as fL and fH respectively. The worst-case frequency offset determined in the above methods is added or subtracted from the values of fL and fH to check that the resulting frequencies remain within the band.

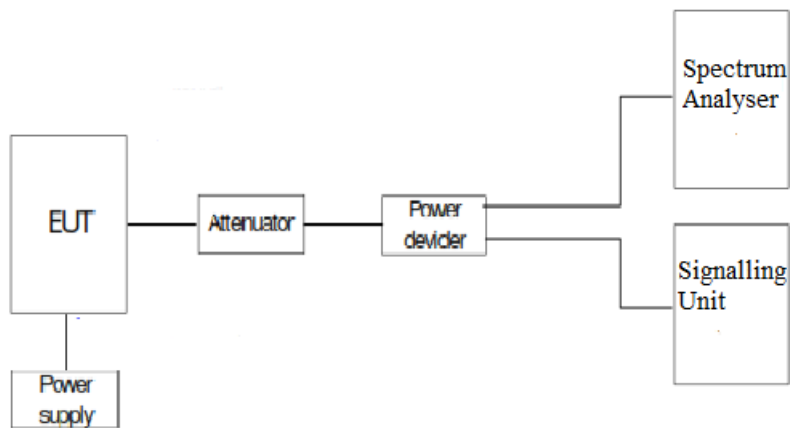
The reference point measurements were made at the RF output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

## TEST SETUP

Frequency tolerance:



Reference points  $f_L$  and  $f_H$ :



**RESULTS**

**LTE Band 5:**

**1. Frequency Tolerance:**

- **Frequency Stability over Temperature Variations:**

| Temperature (°C) | Frequency Error (Hz) | Frequency Error (ppm) |
|------------------|----------------------|-----------------------|
| +50              | -8.62                | -0.010304842          |
| +40              | -7.66                | -0.009157203          |
| +30              | -7.51                | -0.008977884          |
| +20              | -13.88               | -0.016592947          |
| +10              | -7.33                | -0.008762702          |
| 0                | -3.05                | -0.003646145          |
| -10              | -12.42               | -0.014847579          |
| -20              | -8.40                | -0.010041841          |
| -30              | -7.70                | -0.009205021          |

- **Frequency Stability over Voltage Variations.**

| Supply voltage | Voltage (V) | Frequency Error (Hz) | Frequency Error (ppm) |
|----------------|-------------|----------------------|-----------------------|
| Vmax           | 3.795       | -16.82               | -0.020107591          |
| Vmin           | 2.805       | -6.07                | -0.007256426          |

**2. Reference Frequency Points fL and fH:**

The worst-case frequency offsets added or subtracted per band and bandwidth:

QPSK. Nominal Bandwidth 5 MHz.

|                      |            |
|----------------------|------------|
| f <sub>L</sub> (MHz) | 824.089000 |
| f <sub>H</sub> (MHz) | 848.925670 |

The reference frequency points f<sub>L</sub> and f<sub>H</sub> stay within the authorized blocks for the band above.

Measurement uncertainty (Hz) <± 249.55

Verdict: PASS

## Modulation Characteristics

### SPECIFICATION

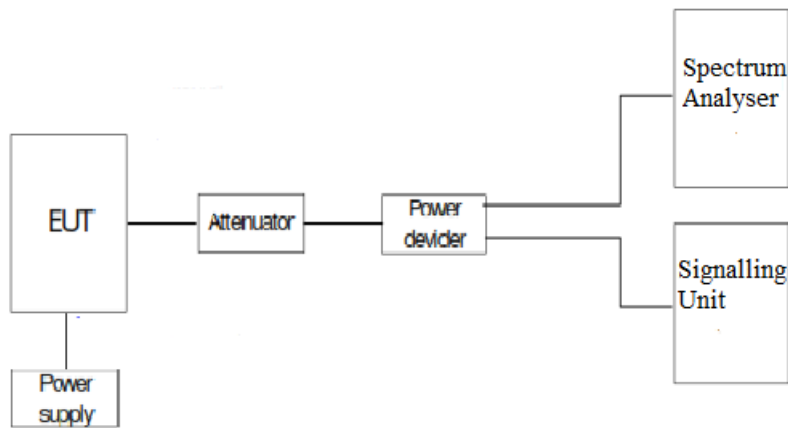
FCC §2.1047.

RSS-132. Clause 5.2: Equipment certified under this standard shall use digital modulation.

### METHOD

For LTE the EUT operates with QPSK and 16QAM modulation modes in which the information is digitized and coded into a bit stream. The RF transmission is multiplexed using *Orthogonal Frequency Division Multiplexing (OFDM)* using different possible arrangement of subcarriers (Resource Blocks RB).

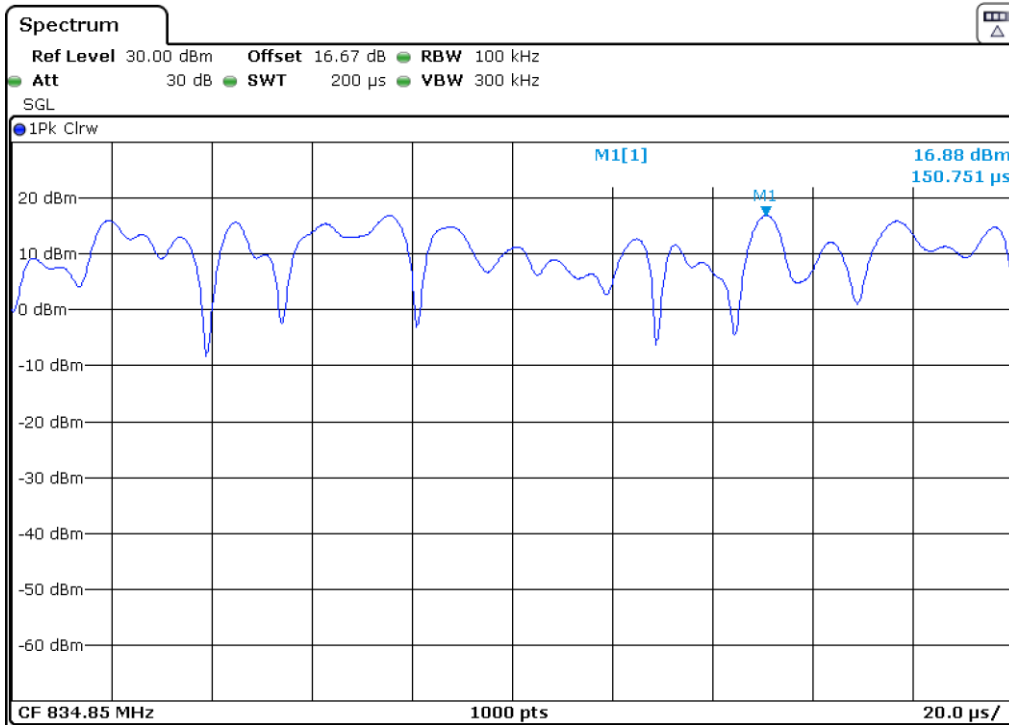
### TEST SETUP



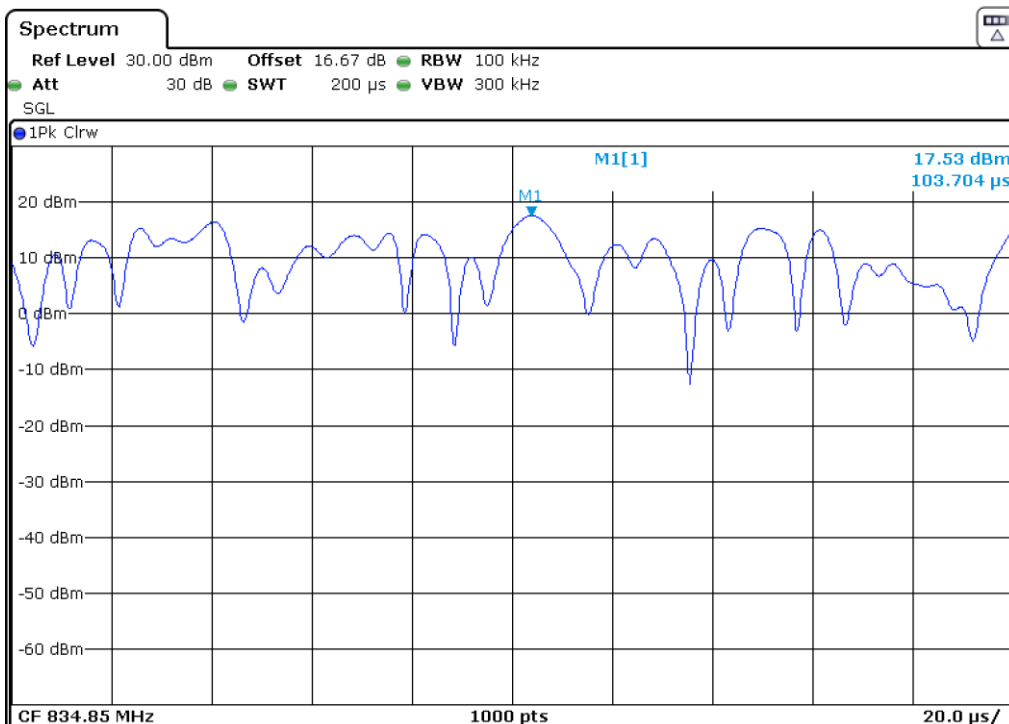
**RESULTS:**

The following plots show the modulation schemes in the EUT.

LTE Band 5. QPSK MODULATION. BW = 5 MHz.



LTE Band 5. 16QAM MODULATION. BW = 5 MHz.



## Occupied Bandwidth

### SPECIFICATION

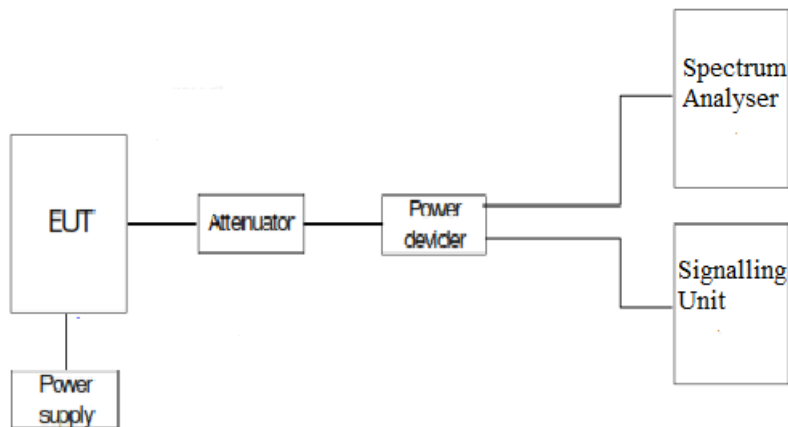
FCC §2.1049. Measurements required: Occupied bandwidth.

RSS-Gen, Clause 6.7.

### METHOD

The occupied bandwidth measurement was performed at the output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation. The 99% occupied bandwidth and the -26 dBc bandwidth were measured directly using the built-in bandwidth measuring option of spectrum analyser.

### TEST SETUP





**RESULTS**

The worst case of Occupied Bandwidth corresponds to Resource Blocks (RB), 6 for QPSK and 5 for 16QAM, with Offset 0, Narrowband 0 (Position 1), regardless the nominal bandwidth selected.

**LTE Band 5:**

LTE Band 5. QPSK MODULATION. BW = 5 MHz. Narrowband = 0, Position 1.

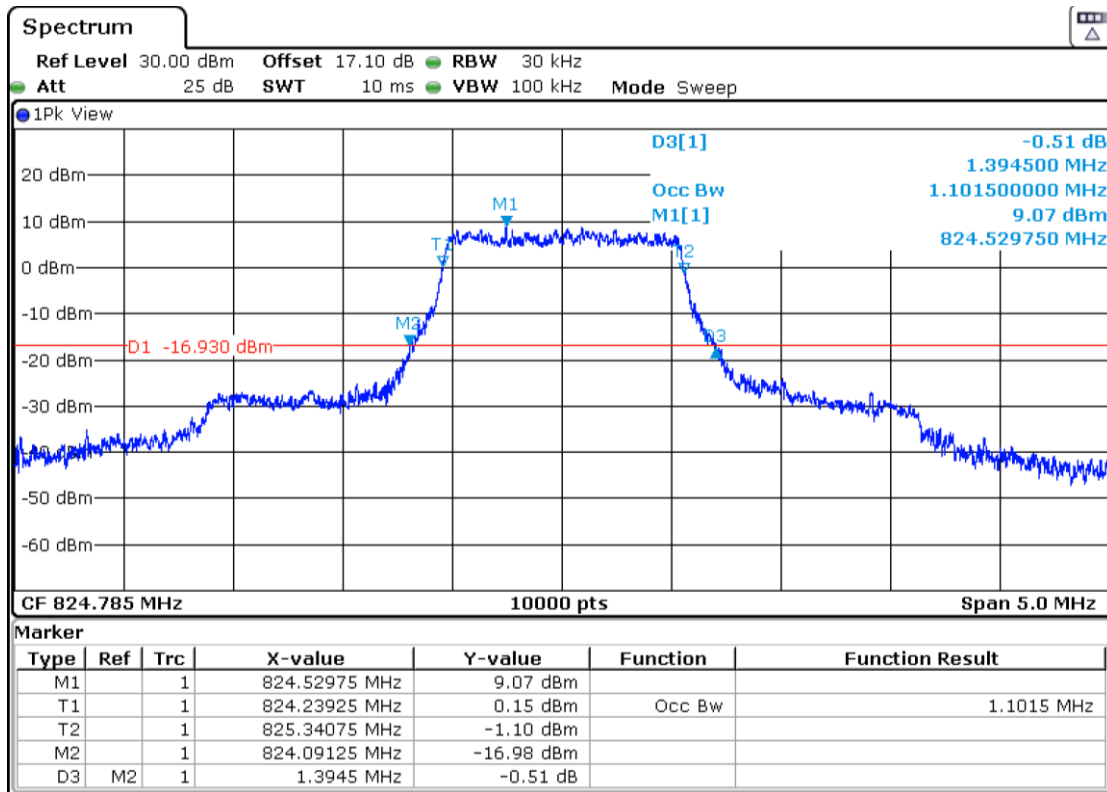
|                               | Low Channel | Middle Channel | High Channel |
|-------------------------------|-------------|----------------|--------------|
| 99% Occupied bandwidth (MHz)  | 1.101500    | 1.103000       | 1.106500     |
| -26 dBc bandwidth (MHz)       | 1.394500    | 1.384500       | 1.400000     |
| Measurement uncertainty (kHz) | <±3.75      |                |              |

LTE Band 5. 16QAM MODULATION. BW = 5 MHz. Narrowband = 0, Position 1.

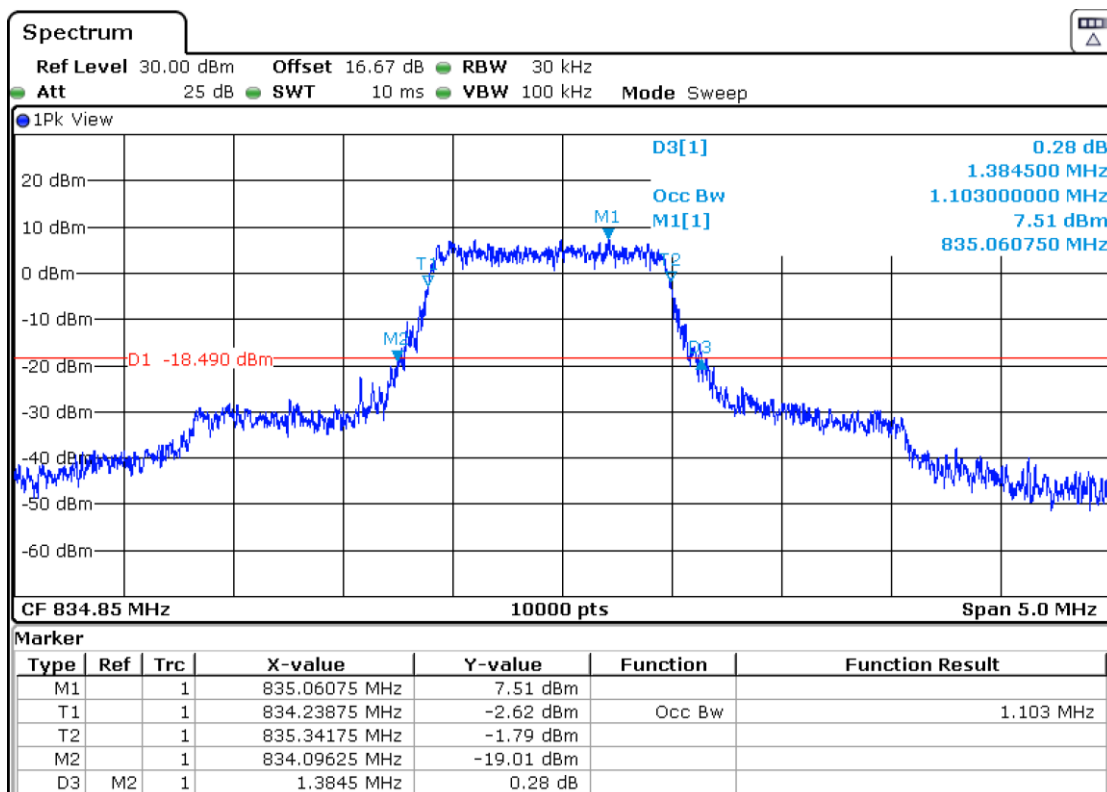
|                               | Low Channel | Middle Channel | High Channel |
|-------------------------------|-------------|----------------|--------------|
| 99% Occupied bandwidth (MHz)  | 0.962000    | 0.948500       | 0.957000     |
| -26 dBc bandwidth (MHz)       | 1.342000    | 1.365000       | 1.350500     |
| Measurement uncertainty (kHz) | <±3.75      |                |              |

LTE Band 5. QPSK MODULATION. BW = 5 MHz. Narrowband = 0. Position 1.

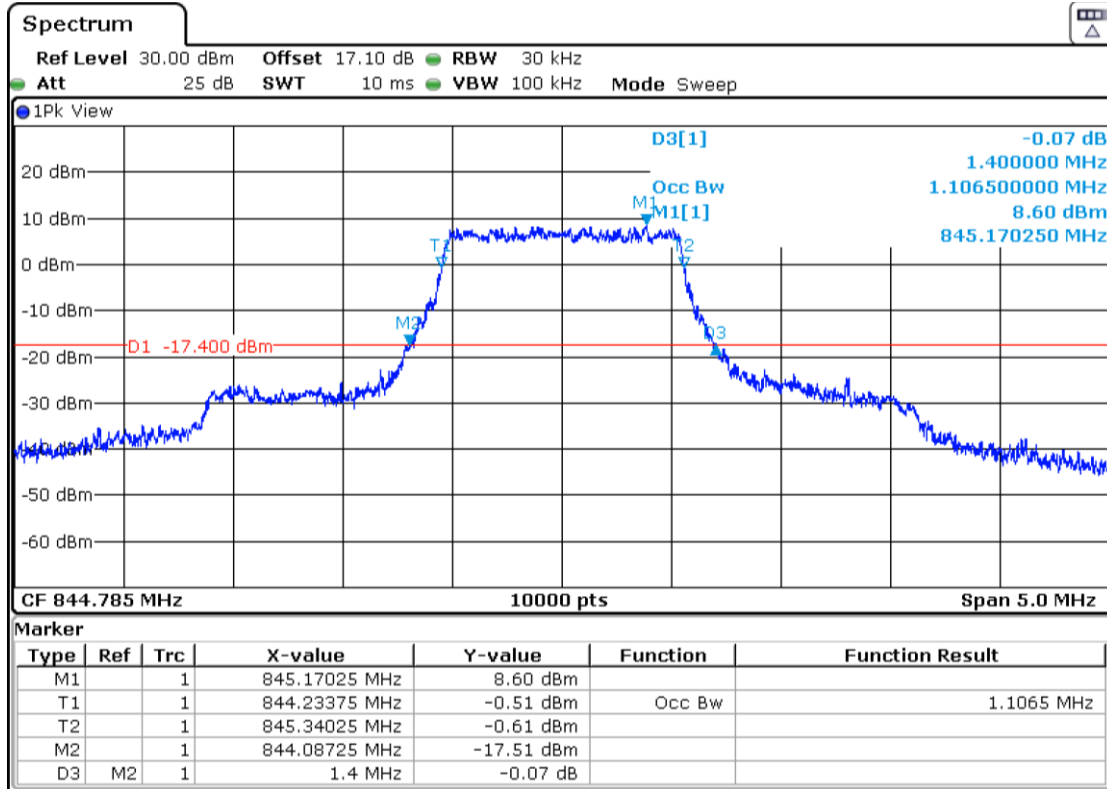
Low Channel:



Middle Channel:

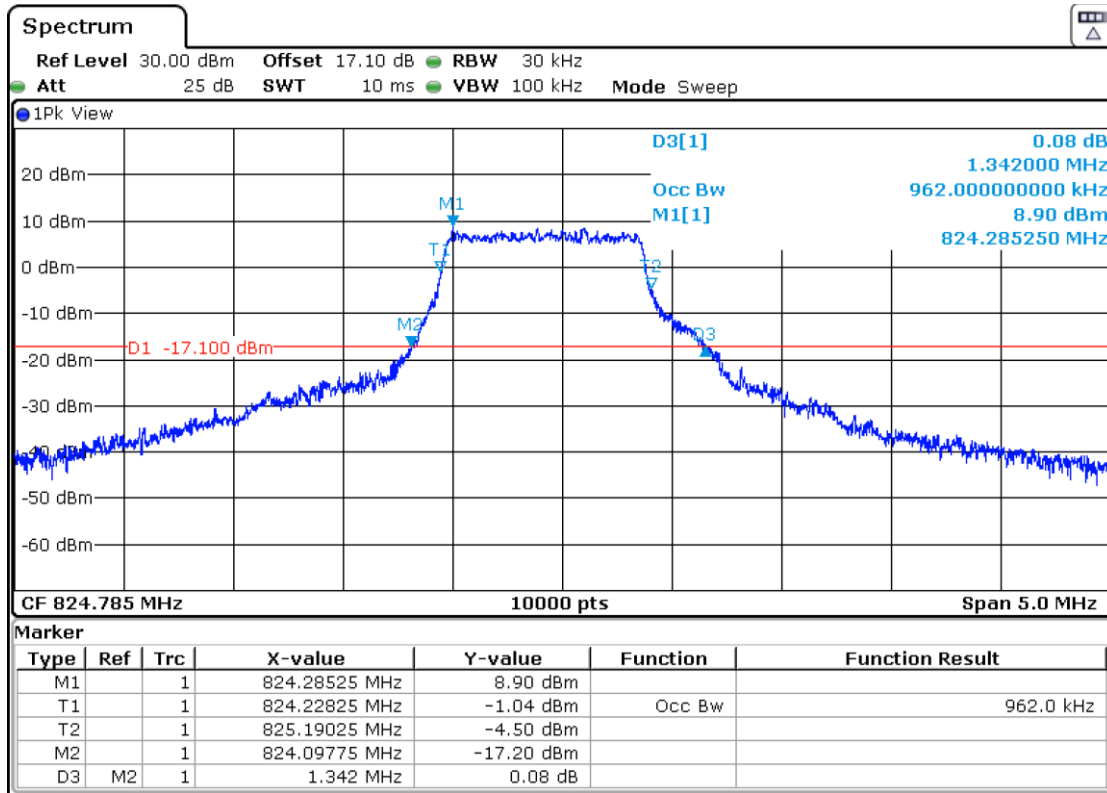


High Channel:

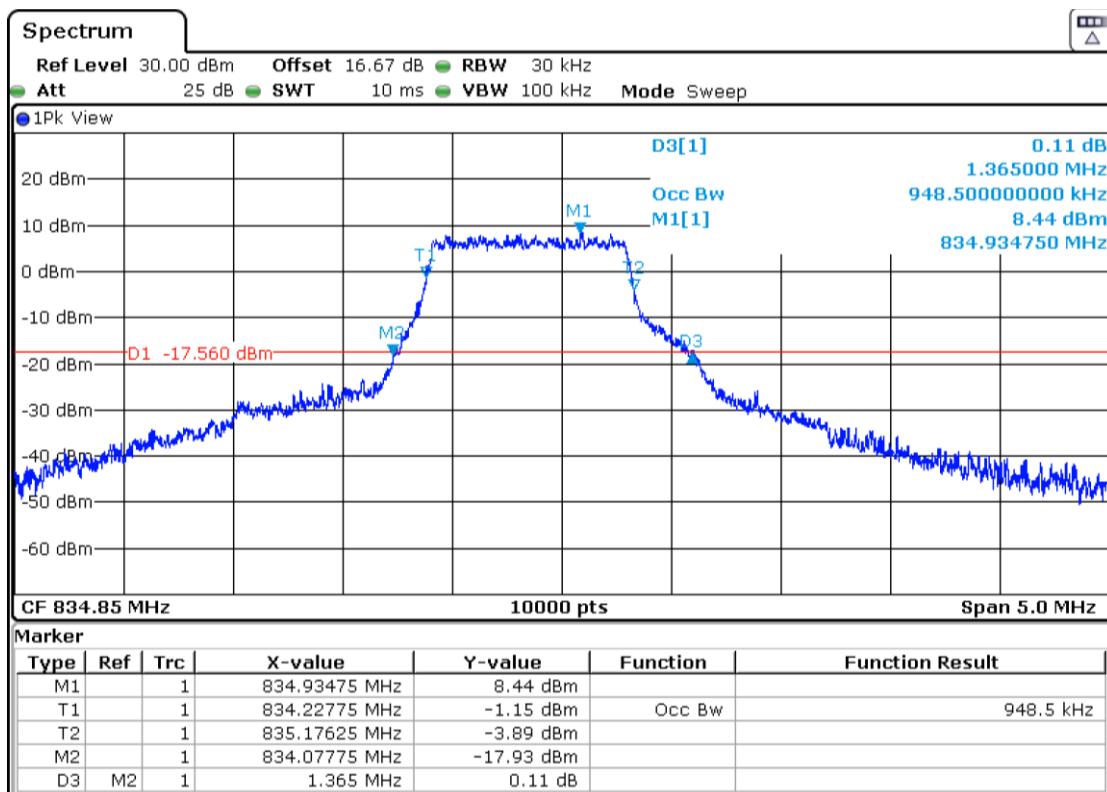


LTE Band 5. 16QAM MODULATION. BW = 5 MHz. Narrowband = 0. Position 1.

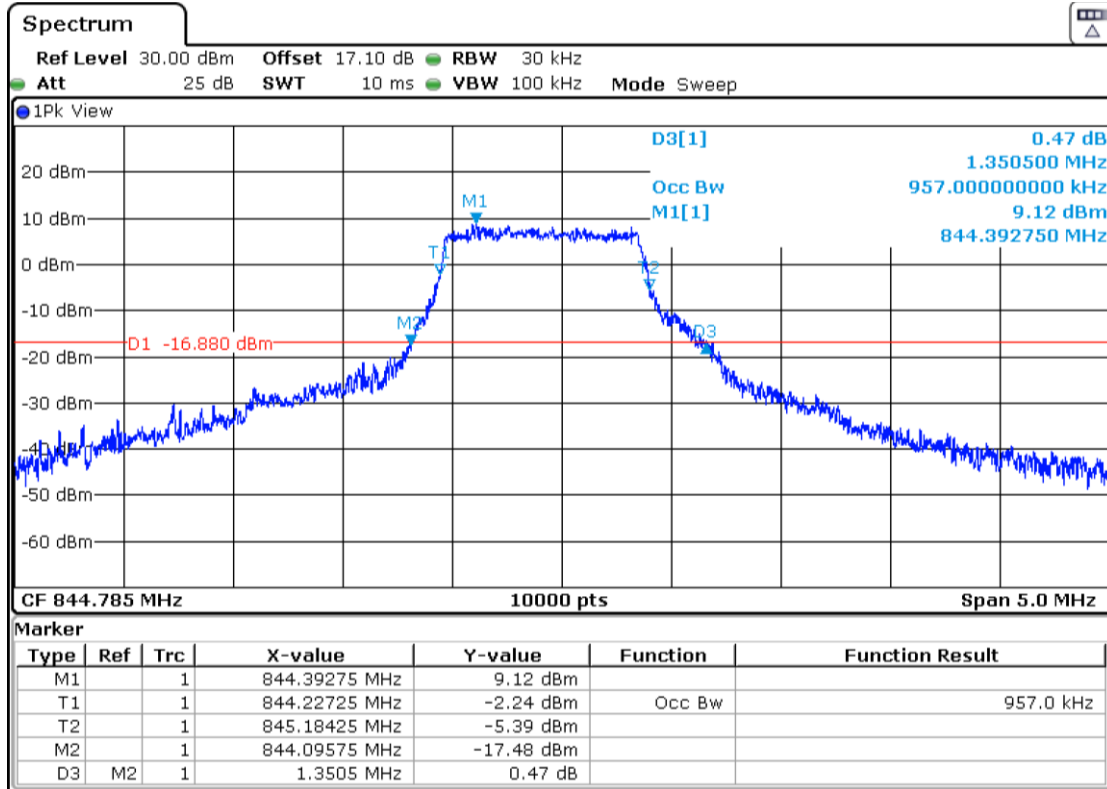
Low Channel:



Middle Channel:



High Channel:



## Spurious emissions at antenna terminals

### SPECIFICATION

FCC §2.1051 and §22.917. RSS-132 Clause 5.5.

The power of emissions shall be attenuated below the transmitter power (P) by a factor of at least  $43 + 10 \log (P)$  dB. P in watts.

In the spectrum below 1 GHz, instrumentation should employ a reference bandwidth of 100 kHz or greater.  
In the spectrum above 1 GHz, instrumentation should employ a reference bandwidth of 1 MHz.

At  $P_o$  transmitting power, the specified minimum attenuation becomes  $43+10 \log (P_o)$ , and the level in dBm relative to  $P_o$  becomes:

$$P_o \text{ (dBm)} - [43 + 10 \log (P_o \text{ in mW}) - 30] = -13 \text{ dBm}$$

### METHOD

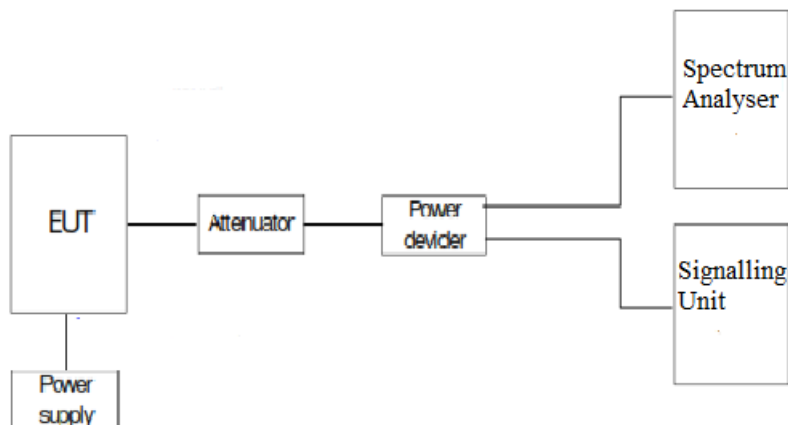
The EUT RF output connector was connected to a spectrum analyser and to the Universal Radio Communication tester R&S CMW500 (selecting maximum transmission power of the EUT and different modes of modulation) using a 50-Ohm attenuator and a power divider.

The spectrum was investigated from 9 kHz to 8.5 GHz.

The reading of the spectrum analyser is corrected with the attenuation loss of connection between output terminal of EUT and input of the spectrum analyser.

The configuration of Resource Blocks and modulation which is the worst case for conducted power was used.

### TEST SETUP



## RESULTS

**LTE Band 5:** QPSK. Nominal Bandwidth 5 MHz. RB Size 1, RB Offset 0. Narrowband 0, Position 1.

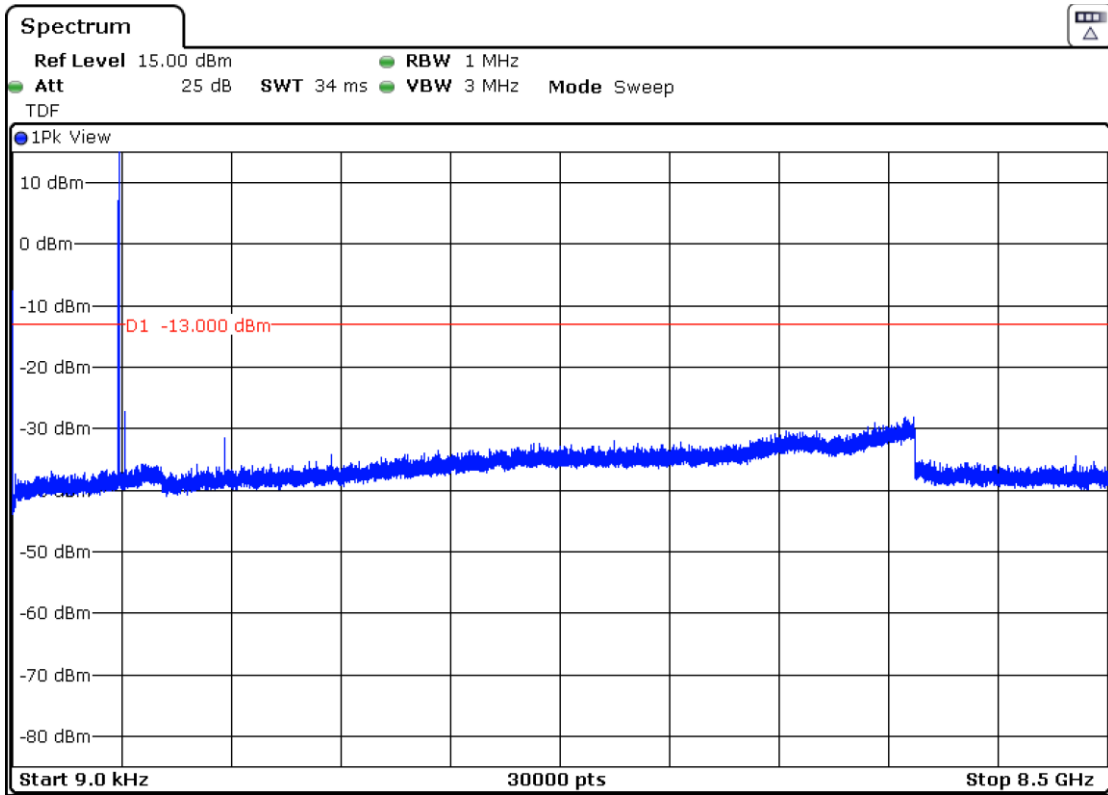
- Low Channel: No spurious frequencies at less than 20 dB below the limit.
- Middle Channel: No spurious frequencies at less than 20 dB below the limit.
- High Channel: No spurious frequencies at less than 20 dB below the limit.

Measurement uncertainty (dB):  $<\pm 2.76$

Verdict: PASS

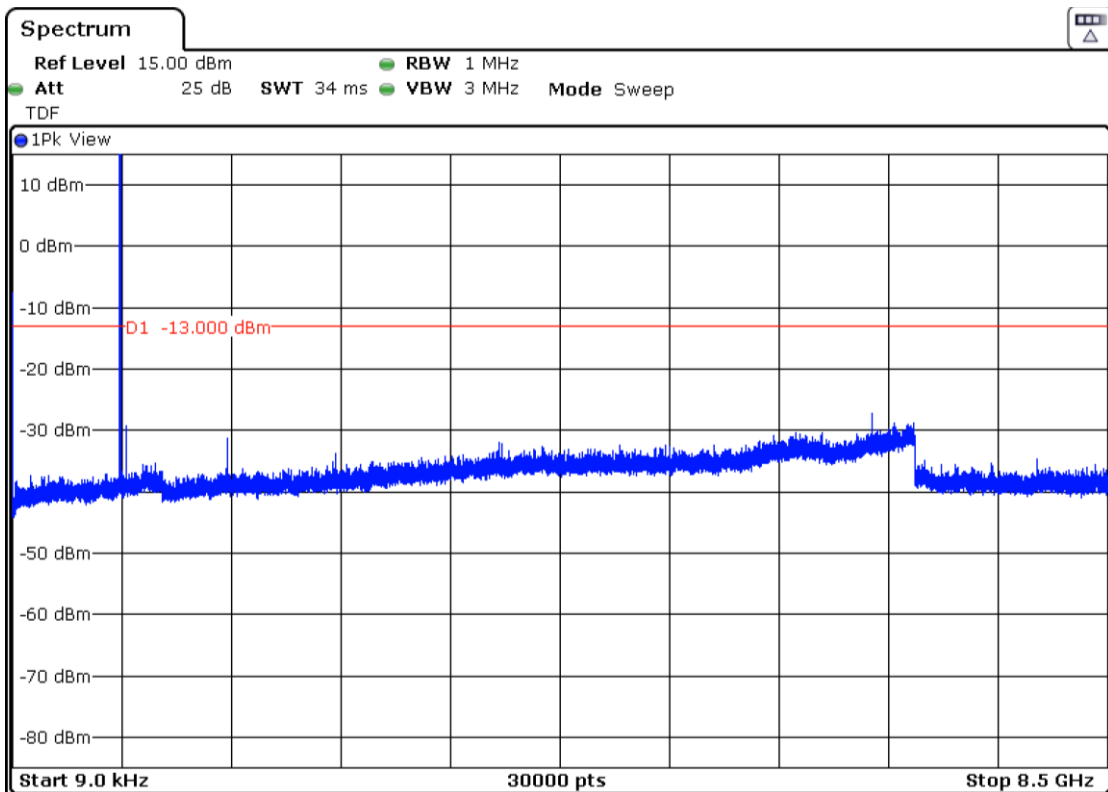
LTE Band 5. QPSK. Nominal Bandwidth 5 MHz. RB Size 1, RB Offset 0. Narrowband 0, Position 1.

Low Channel:



The peak above the limit is the carrier frequency.

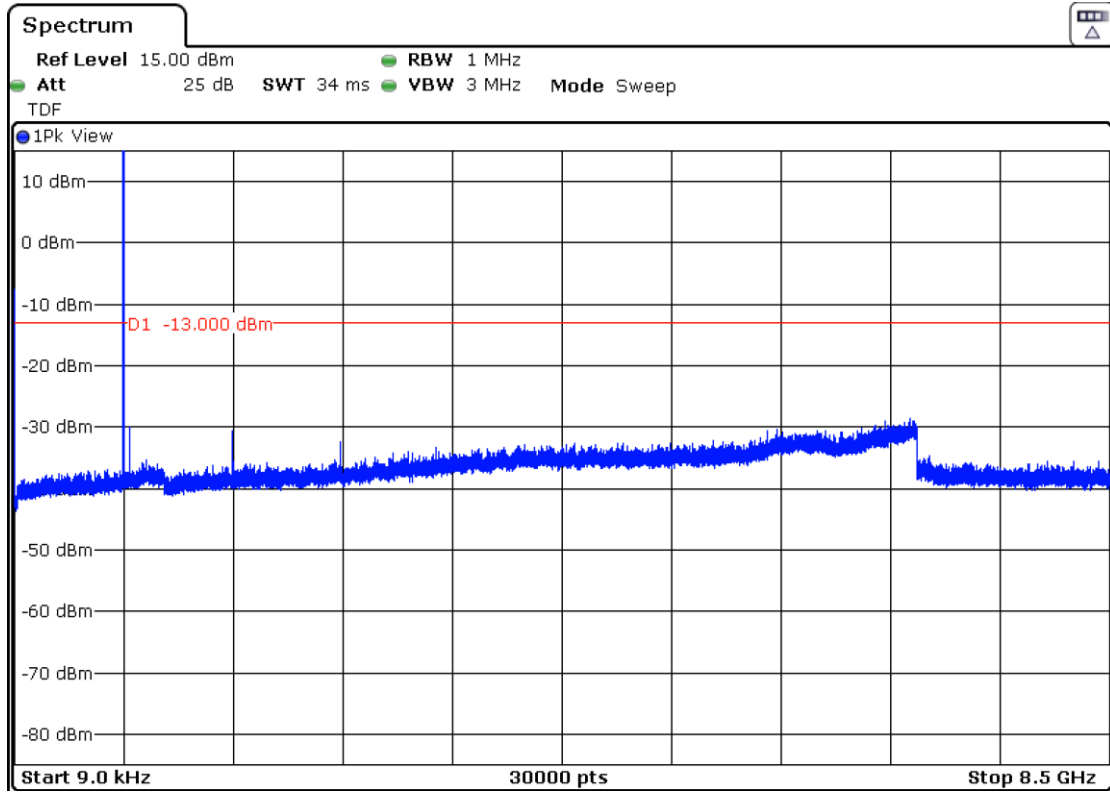
Middle Channel:



The peak above the limit is the carrier frequency.



High Channel:



The peak above the limit is the carrier frequency.

## Spurious emissions at antenna terminals at Block Edges

### SPECIFICATION

FCC §2.1051 and §22.917. RSS-132 Clause 5.5.

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.

At  $P_o$  transmitting power, the specified minimum attenuation becomes  $43+10 \log (P_o)$ , and the level in dBm relative to  $P_o$  becomes:

$$P_o \text{ (dBm)} - [43 + 10 \log (P_o \text{ in mW}) - 30] = -13 \text{ dBm}$$

### METHOD

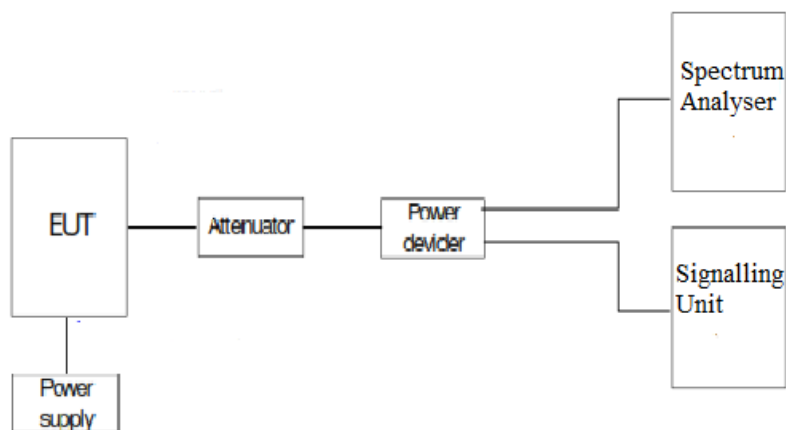
The EUT RF output connector was connected to a spectrum analyser and to the Universal Radio Communication tester R&S CMW500 (selecting maximum transmission power of the EUT and different modes of modulation) using a 50-Ohm attenuator and a power splitter.

The reading of the spectrum analyser is corrected with the attenuation loss of connection between output terminal of EUT and input of the spectrum analyser.

The configuration of modulation which is the worst case for conducted power was used.

As stated in FCC part 22.917 / RSS-132 Clause 5.5, in the 1 MHz bands immediately outside and adjacent to the frequency block or band a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed.

### TEST SETUP



**RESULTS**

**LTE Band 5:**

Preliminary measurements determined QPSK as the worst-case modulation in terms of band edge results. The next results are for this worst-case configuration.

Low Block Edge. Narrowband = 0.

|  |                                    |                                     |
|--|------------------------------------|-------------------------------------|
| LTE QPSK MODULATION:   | RB=1.<br>Offset = 0.<br>BW = 5 MHz | RB=1.<br>Offset = 0.<br>BW = 10 MHz |
| Maximum measured level at <u>Lowest Block Edge</u> at antenna port (dBm) | -22.19                             | -32.77                              |

|  |  |   |
|--|--|---|
| LTE QPSK MODULATION:   | RB = All.<br>Offset = 0.<br>BW = 5 MHz | RB = All.<br>Offset = 0.<br>BW = 10 MHz |
| Maximum measured level at <u>Lowest Block Edge</u> at antenna port (dBm) | -24.18                                 | -24.55                                  |

High Block Edge. Narrowband = Max.

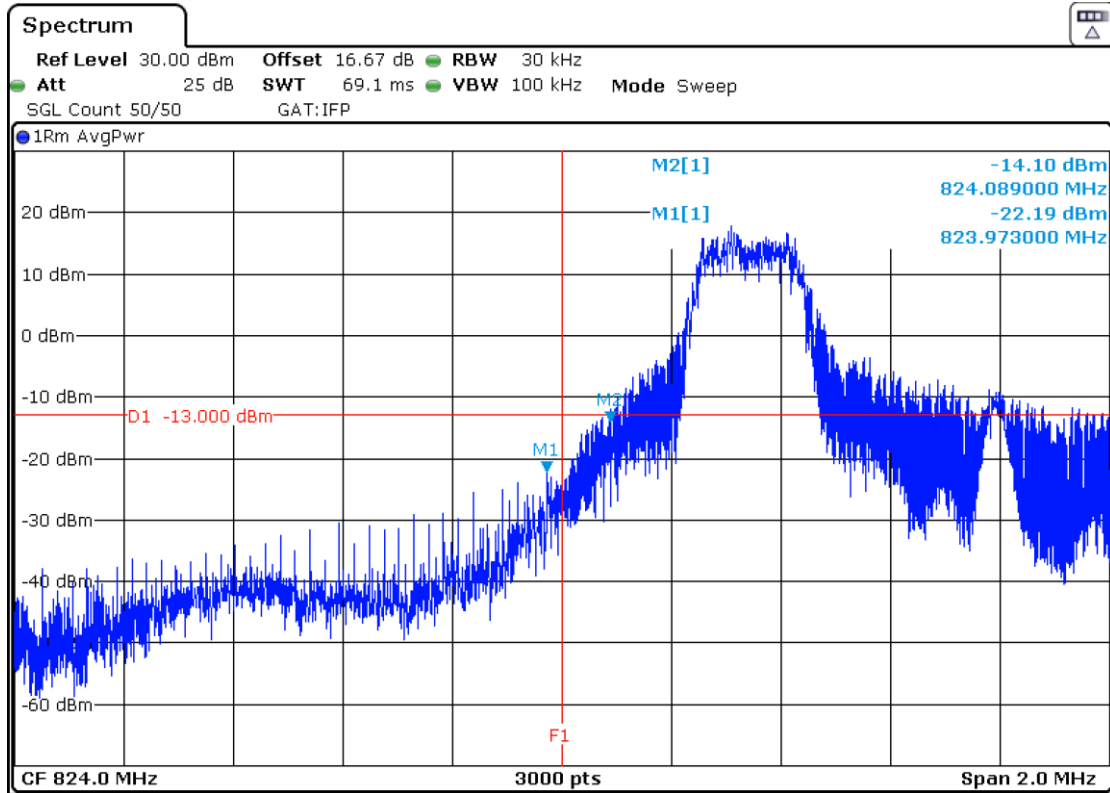
|   |                                    |                                     |
|---|------------------------------------|-------------------------------------|
| LTE QPSK MODULATION:  | RB=1.<br>Offset=Max.<br>BW = 5 MHz | RB=1.<br>Offset=Max.<br>BW = 10 MHz |
| Maximum measured level at <u>Highest Block Edge</u> at antenna port (dBm) | -21.63                             | -31.81                              |

|   |  |   |
|---|--|---|
| LTE QPSK MODULATION:  | RB = All.<br>Offset = 0.<br>BW = 5 MHz | RB = All.<br>Offset = 0.<br>BW = 10 MHz |
| Maximum measured level at <u>Highest Block Edge</u> at antenna port (dBm) | -22.37                                 | -25.19                                  |

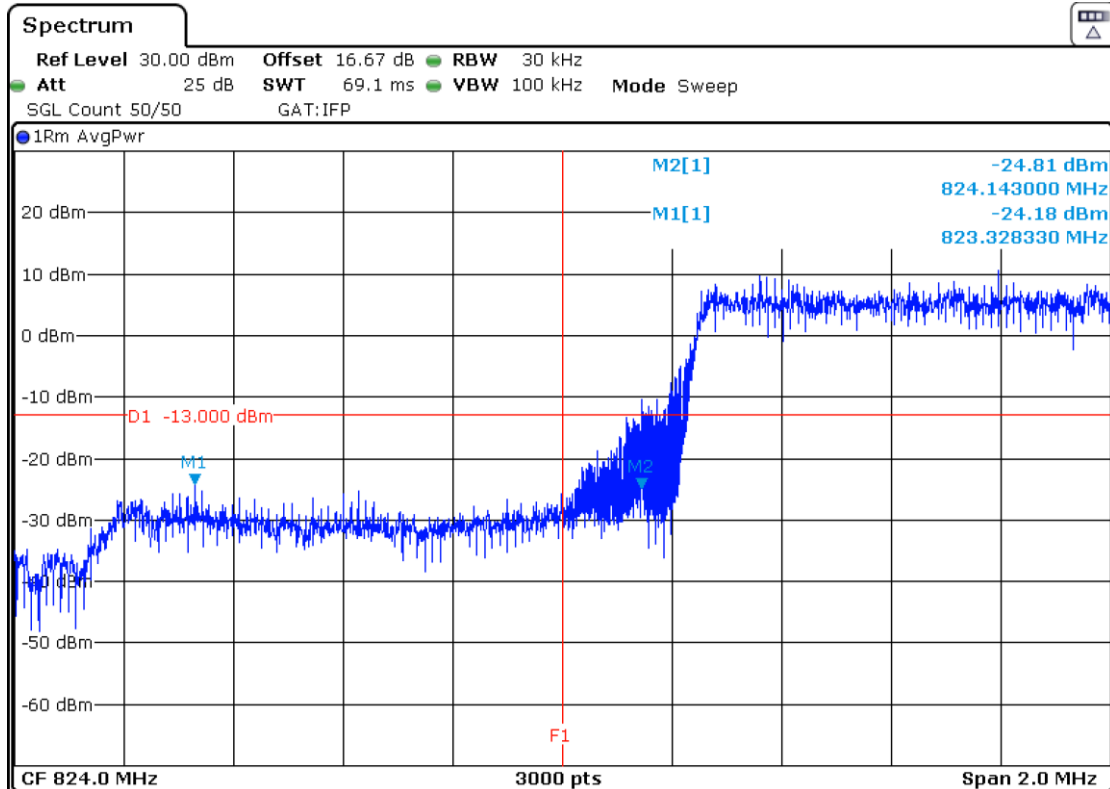
Measurement uncertainty: <±2.76 dB

Verdict: PASS

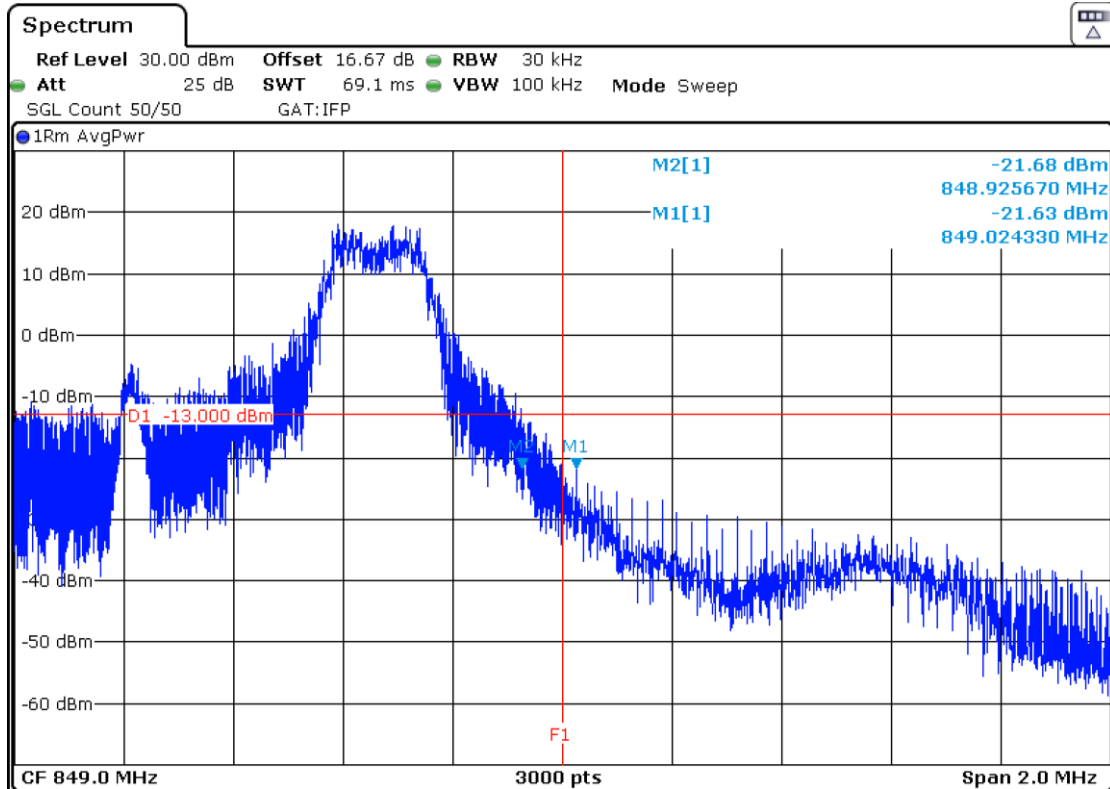
LTE Band 5. QPSK MODULATION. BW=5 MHz. RB=1. Offset=0. Narrowband=0. Low Block Edge:



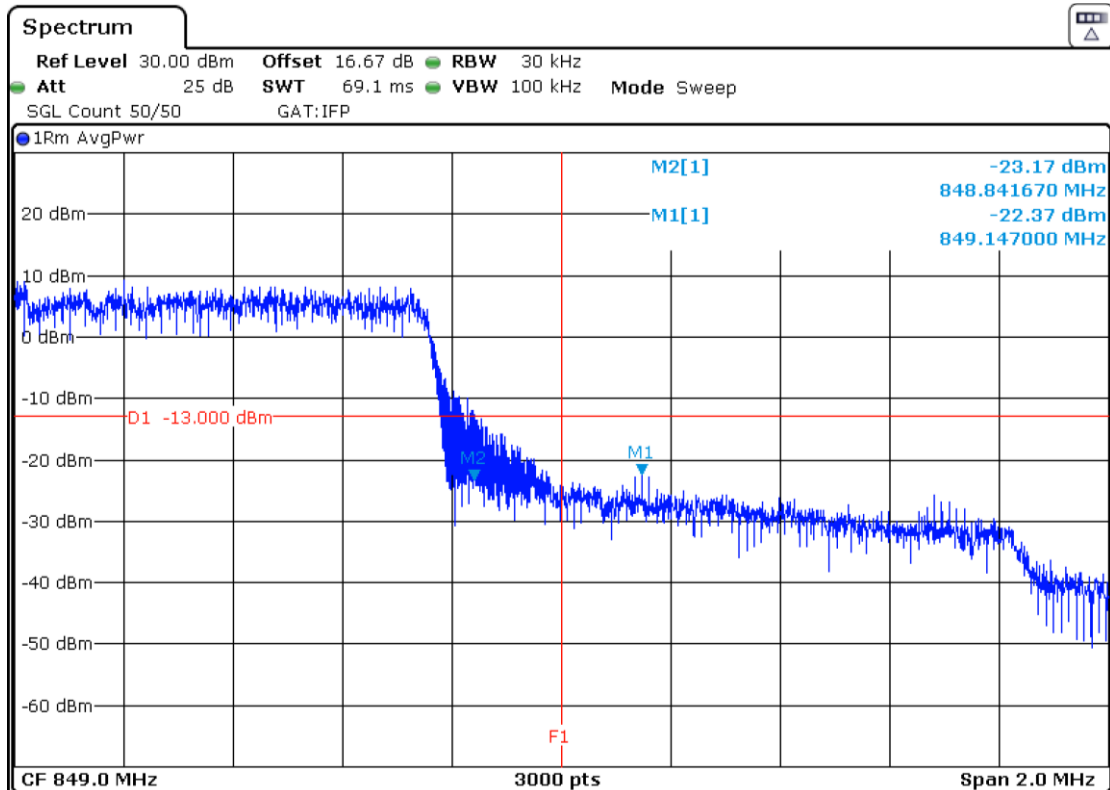
LTE Band 5. QPSK MODULATION. BW=5 MHz. RB=All. Offset=0. Narrowband=0. Low Block Edge:



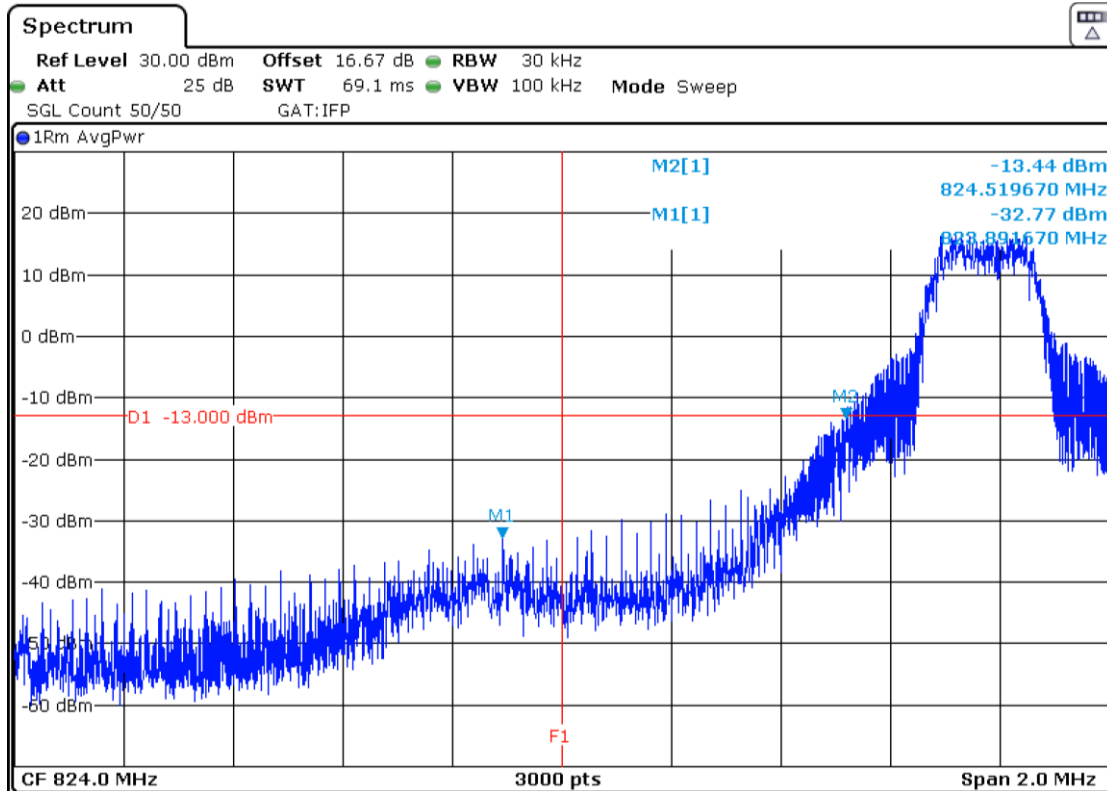
LTE Band 5. QPSK MODULATION. BW=5 MHz. RB=1. Offset=Max. Narrowband=3. High Block Edge:



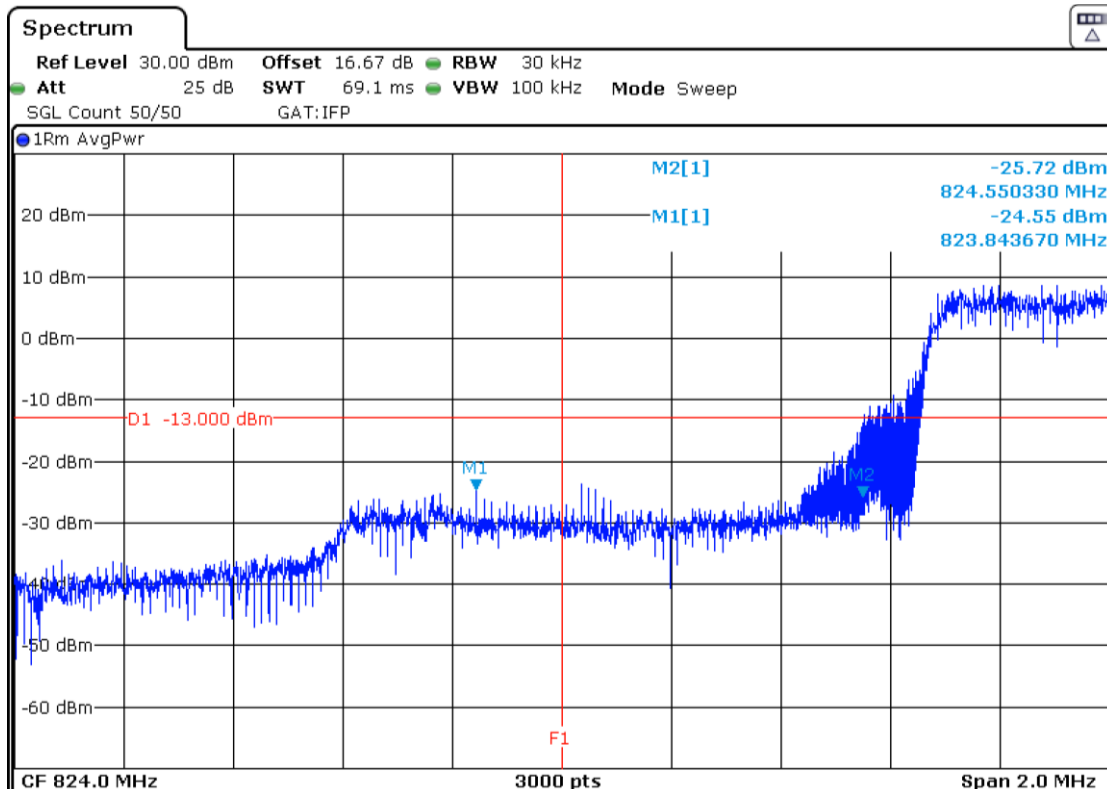
LTE Band 5. QPSK MODULATION. BW=5 MHz. RB=All. Offset=0. Narrowband=3. High Block Edge:



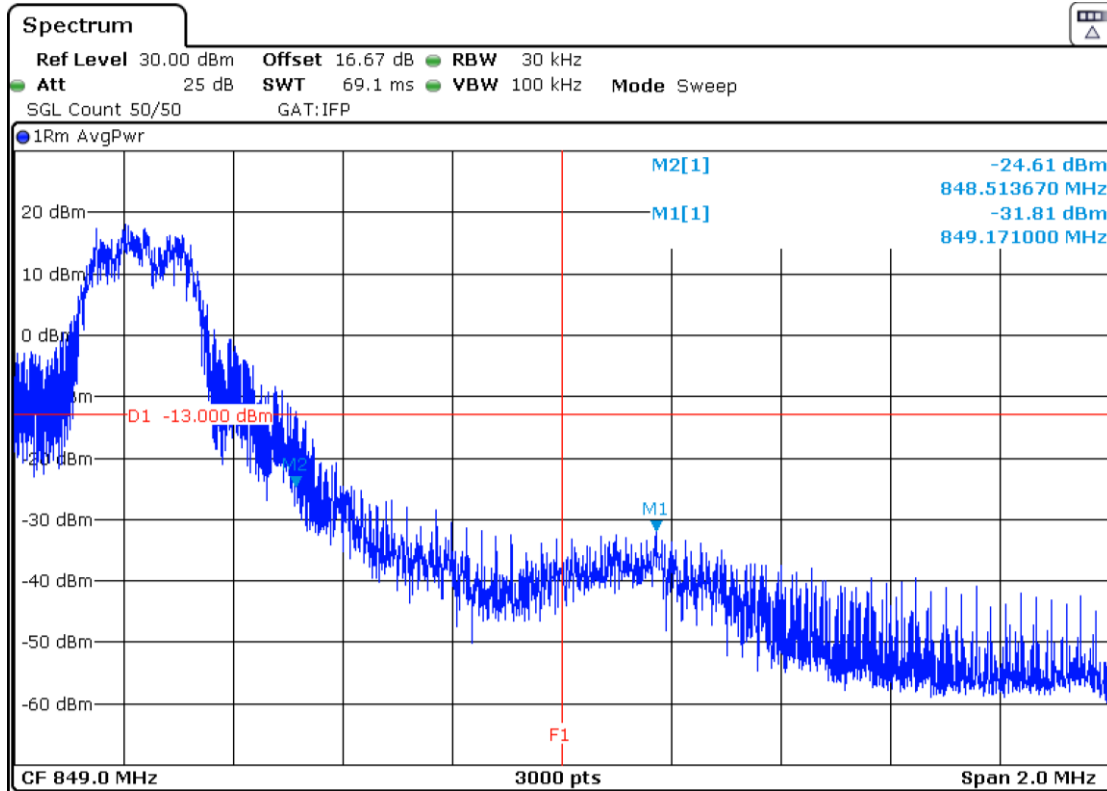
LTE Band 5. QPSK MODULATION. BW=10 MHz. RB=1. Offset=0. Narrowband=0. Low Block Edge:



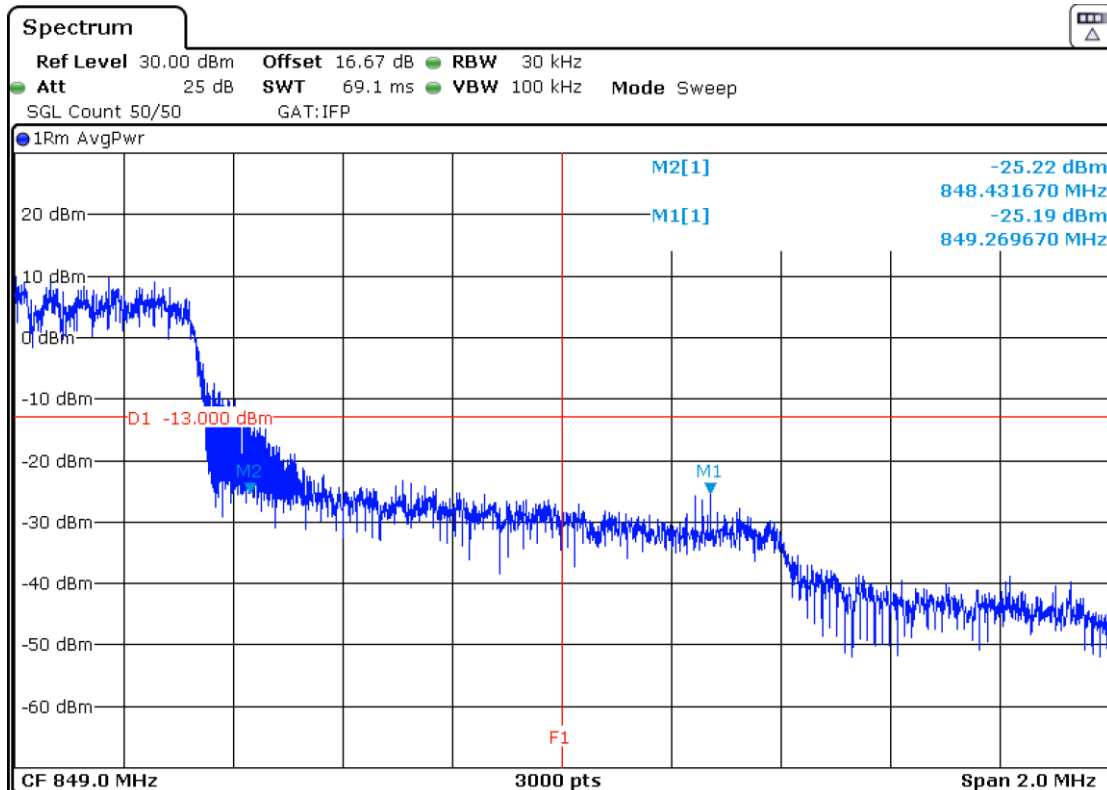
LTE Band 5. QPSK MODULATION. BW=10 MHz. RB=All. Offset=0. Narrowband=0. Low Block Edge:



LTE Band 5. QPSK MODULATION. BW=10 MHz. RB=1. Offset=Max. Narrowband=7. High Block Edge:



LTE Band 5. QPSK MODULATION. BW=10 MHz. RB=All. Offset=0. Narrowband=7. High Block Edge:



## Radiated emissions

### SPECIFICATION

FCC §2.1051 and §22.917. RSS-132 Clause 5.5.

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.

In the spectrum below 1 GHz, instrumentation should employ a reference bandwidth of 100 kHz or greater. In the spectrum above 1 GHz, instrumentation should employ a reference bandwidth of 1 MHz.

At  $P_o$  transmitting power, the specified minimum attenuation becomes  $43+10 \log (P_o)$ , and the level in dBm relative to  $P_o$  becomes:

$$P_o \text{ (dBm)} - [43 + 10 \log (P_o \text{ in mW}) - 30] = -13 \text{ dBm}$$

### METHOD

The measurement was performed with the EUT inside an anechoic chamber. The spectrum was scanned from 30 MHz to at least the 10th harmonic of the highest frequency generated within the equipment.

The EUT was placed on a non-conductive stand at a 3-meter distance from the measuring antenna for measurements from 30 MHz up to 18 GHz.

Detected emissions were maximized at each frequency by rotating the EUT and adjusting the height and polarization of the measuring antenna. The maximum meter reading was recorded.

The maximum field strength (dB $\mu$ V/m) of each detected emission at less than 20 dB respect to the limit is converted to an equivalent EIRP level (dBm) according to ANSI C63.26 with the formula:

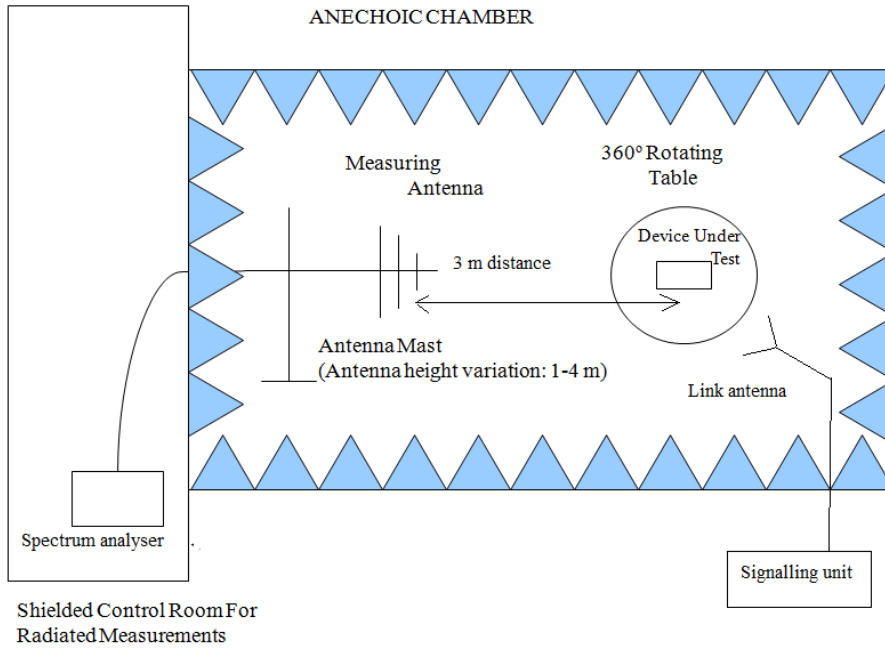
$$\text{EIRP (dBm)} = E(\text{dB}\mu\text{V/m}) + 20 \log (D) - 104.8$$

Where D is the measurement distance (in the far field region) in m.  $D = 3$  m.

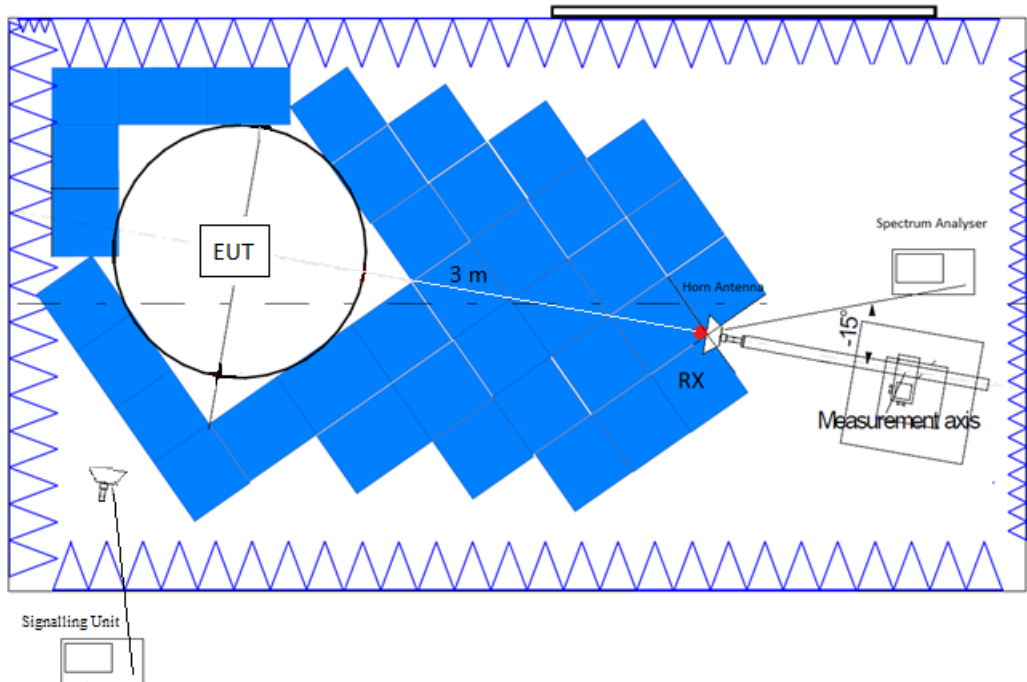


## TEST SETUP

Radiated measurements below 1 GHz.



Radiated measurements above 1 GHz.



## RESULTS

### LTE Band 5:

Preliminary measurements determined QPSK modulation, Nominal Bandwidth of 5 MHz, RB Size 1, RB Offset 0, Narrowband 0 as the worst case in terms of RF Output Power and spurious emissions.

The next results are for this worst-case configuration.

#### - Low Channel:

##### **Frequency range 30 MHz - 1 GHz**

No spurious frequencies at less than 20 dB below the limit.

##### **Frequency range 1 - 8.5 GHz**

Spurious frequencies at less than 20 dB below the limit:

| Spurious frequency (MHz) | E.I.R.P (dBm) | Polarization | Detector |
|--------------------------|---------------|--------------|----------|
| 1648.640625              | -24.85        | H            | Peak     |

#### - Middle Channel:

##### **Frequency range 30 MHz - 1 GHz**

No spurious frequencies at less than 20 dB below the limit.

##### **Frequency range 1 - 8.5 GHz**

Spurious frequencies at less than 20 dB below the limit:

| Spurious frequency (MHz) | E.I.R.P (dBm) | Polarization | Detector |
|--------------------------|---------------|--------------|----------|
| 1668.664375              | -24.22        | H            | Peak     |

#### - High Channel:

##### **Frequency range 30 MHz - 1 GHz**

No spurious frequencies at less than 20 dB below the limit.

##### **Frequency range 1 - 8.5 GHz**

Spurious frequencies at less than 20 dB below the limit:

| Spurious frequency (MHz) | E.I.R.P (dBm) | Polarization | Detector |
|--------------------------|---------------|--------------|----------|
| 1688.782188              | -22.67        | H            | Peak     |

Measurement uncertainty (dB):  $\leq \pm 4.89$  for  $f \geq 30$  MHz up to 1 GHz  
 $\leq \pm 5.13$  for  $f \geq 1$  GHz up to 8.5 GHz

Verdict: PASS

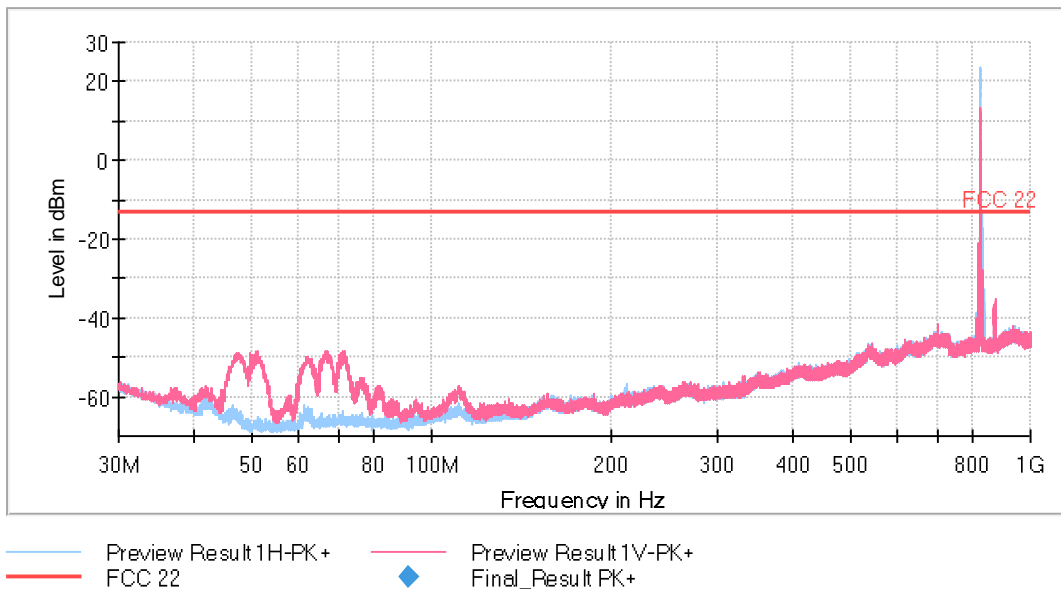
LTE Band 5. QPSK. Nominal Bandwidth 5 MHz. RB Size 1, RB Offset 0. Narrowband = 0.

Measurement settings:

| Subrange                              | Step Size   | Detectors | Bandwidth | Sweep Time | Preamp |
|---------------------------------------|-------------|-----------|-----------|------------|--------|
| Receiver: [ESR 7]<br>30 MHz - 1 GHz   | 30,312 kHz  | PK+       | 1 MHz     | 1 s        | 0 dB   |
| Subrange                              | Step Size   | Detectors | Bandwidth | Sweep Time | Preamp |
| Receiver: [FSV 40]<br>1 GHz - 8,5 GHz | 234,375 kHz | PK+       | 1 MHz     | 1 s        | 0 dB   |

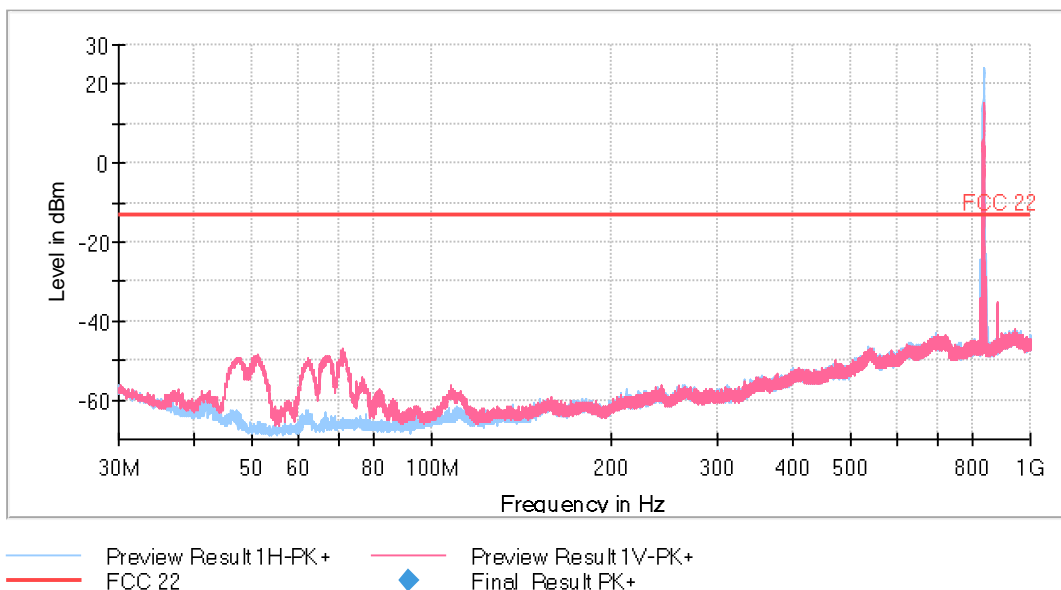
**FREQUENCY RANGE 30 MHz - 1 GHz**

- Low Channel:



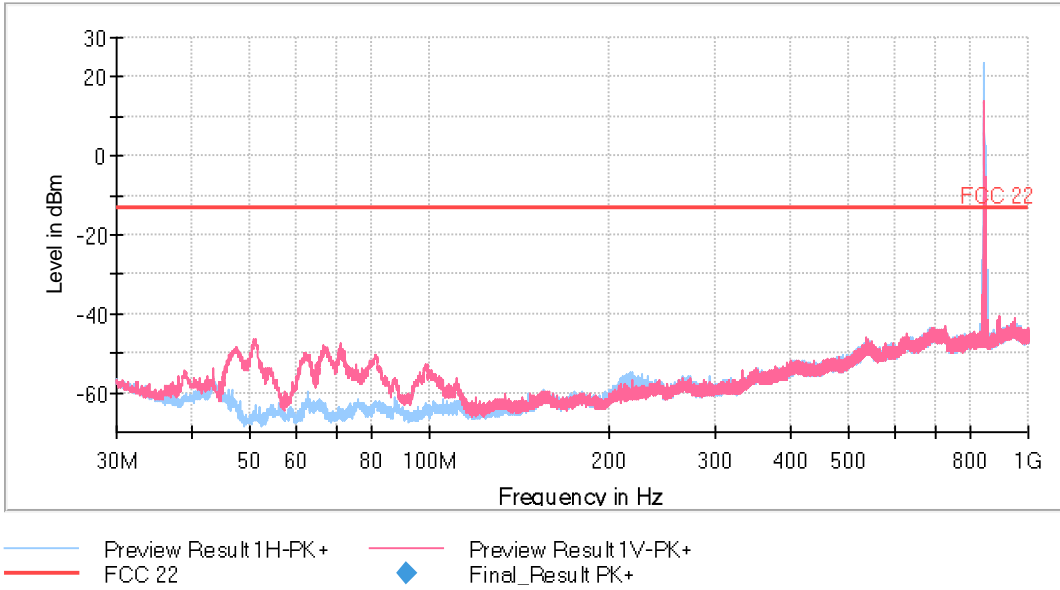
The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.

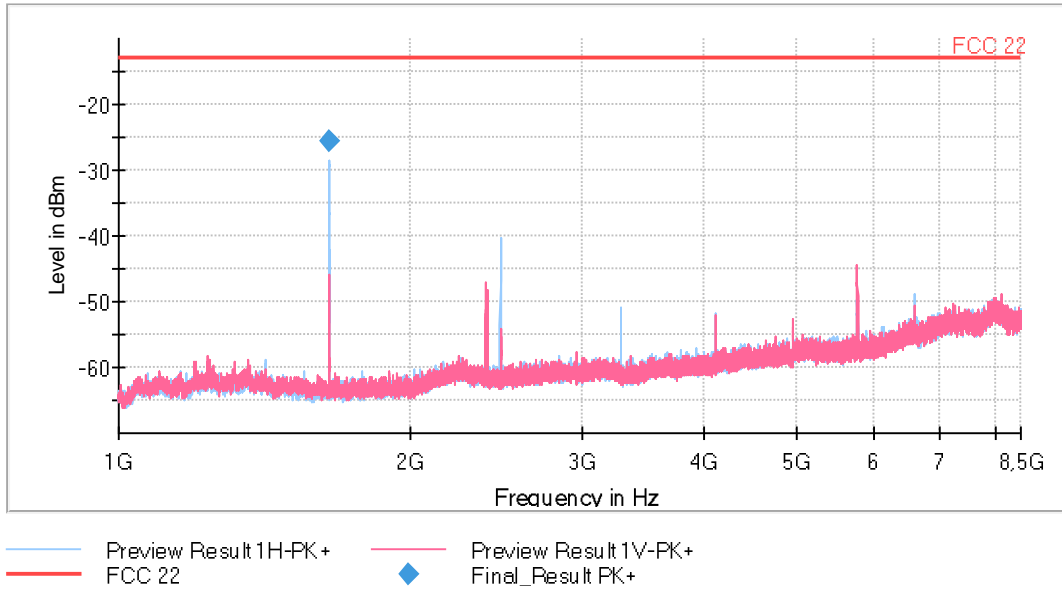
- High Channel:



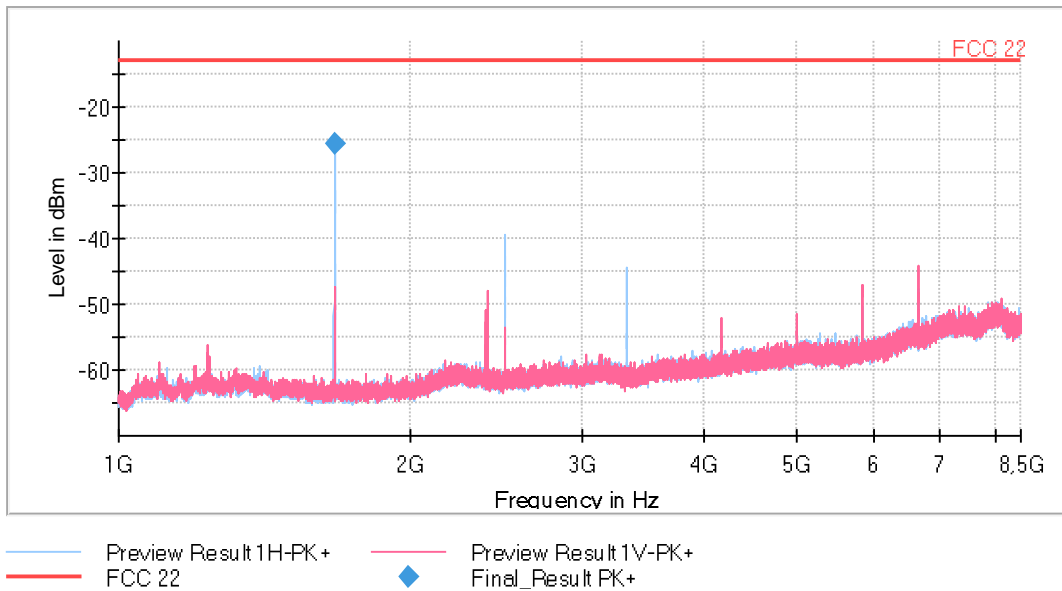
The peak above the limit is the carrier frequency:

### FREQUENCY RANGE 1 GHz — 8.5 GHz

- Low Channel:



- Middle Channel:



- High Channel:

