

ISED CABid: ES1909  
Lab. Company Number: 4621A

Test Report No:  
77535RRF.003

## Test Report

### USA FCC Part 27

### CANADA RSS-Gen, RSS-130, RSS-139

|                                           |                                                                                                                                                                                                                                                                                                                                     |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (*) Identification of item tested         | nRF91                                                                                                                                                                                                                                                                                                                               |
| (*) Trademark                             | nRF91                                                                                                                                                                                                                                                                                                                               |
| (*) Model and /or type reference          | nRF9151                                                                                                                                                                                                                                                                                                                             |
| Other identification of the product       | FCC ID: 2ANPO00nRF9151<br>IC: 24529-NRF9151                                                                                                                                                                                                                                                                                         |
| (*) Features                              | LTE Cat-M1, LTE NB1&NB2<br>HW version: nRF9151 LACA AA<br>SW version: mfw_nrf91x1_2.0.0                                                                                                                                                                                                                                             |
| Applicant                                 | NORDIC SEMICONDUCTOR ASA<br>Otto Nielsens Veg 12, 7052 Trondheim, Norway                                                                                                                                                                                                                                                            |
| Test method requested, standard           | USA FCC Part 27 (10-1-22 Edition).<br>CANADA RSS-Gen Issue 5, April 2018, Amendment March 2019, Amendment February 2021.<br>CANADA RSS-130 Issue 2, February 2019.<br>CANADA RSS-139 Issue 4 September 2022, Amendment October 2022.<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) | José Manuel Gómez Galván<br>EMC Consumer & RF<br>Lab. Manager                                                                                                                                                                                                                                                                       |
| Date of issue                             | 2024-03-21                                                                                                                                                                                                                                                                                                                          |
| Report template No.                       | FDT08_24<br>(*) "Data provided by the client"                                                                                                                                                                                                                                                                                       |

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## Competences and guarantees

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DEKRA Testing and Certification is an ISED-recognized accredited testing laboratory, CABid: ES1909, Company Number: 4621A, with the appropriate scope of accreditation that covers the performed tests in this report.

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## General conditions

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## Uncertainty

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

## Data provided by the client

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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 nRF9151 DK is a Development Kit that has nRF9151 IOT Module and GPS. The nRF9151 is capable of LTE Cat-M1, Cat-NB1&NB2 and GPS. The Development kit contains antennas for cellular and GPS.

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.

| Id   | Control Number | Description | Model   | HW Version       | Serial N°  | Date Reception | of | Application        |
|------|----------------|-------------|---------|------------------|------------|----------------|----|--------------------|
| S/01 | 77535C/025_.1  | nRF91       | nRF9151 | nRF9151 LACA CB0 | 1051231716 | 2024-01-08     |    | Element Under Test |
| S/01 | 77535C/022_.1  | SMA Cable   | -       |                  | -          | 2024-01-08     |    | Auxiliary Element  |
| S/01 | 77535C/013_.1  | USB Cable   | -       |                  | -          | 2024-01-08     |    | Auxiliary Element  |
| S/02 | 77535C/027_.1  | nRF91       | nRF9151 | nRF9151 LACA CB0 | 1051275581 | 2024-01-08     |    | Element Under Test |
| S/02 | 77535C/023_.1  | SMA Cable   | -       |                  | -          | 2024-01-08     |    | Auxiliary Element  |
| S/02 | 77535C/015_.1  | USB Cable   | -       |                  | -          | 2024-01-08     |    | Auxiliary Element  |
| S/03 | 77535C/026_.1  | nRF91       | nRF9151 | nRF9151 LACA CB0 | 1051261483 | 2024-01-08     |    | Element Under Test |
| S/03 | 77535C/012_.1  | USB Cable   | -       |                  | -          | 2023-12-15     |    | Auxiliary Element  |
| S/04 | 77535C/036_.1  | nRF91       | nRF9151 | nRF9151 LACA AA  | 1051266193 | 2024-01-29     |    | Element Under Test |
| S/04 | 77535C/015_.1  | USB Cable   | -       | -                | -          | 2024-01-08     |    | Auxiliary Element  |

Notes referenced to samples during the project:

| Id   | Type                                                                                                                                 |
|------|--------------------------------------------------------------------------------------------------------------------------------------|
| S/01 | Conducted tests: The RF Output Power and PAPR tests of the LTE Cat-M1 Band 12 and Band 13.                                           |
| S/02 | Conducted tests: LTE Cat-M1 Band 12 and Band 13 but the RF Output Power and PAPR tests, and the LTE Cat-M1 Band 17 Block Edge tests. |
| S/03 | Radiated tests.                                                                                                                      |
| S/04 | Radiated test. Testing only in B85 Cat-M1.                                                                                           |

## Test sample description

| Ports.....:                                  | Port name and description | Cable                    |                                     |                                     |                                   |
|----------------------------------------------|---------------------------|--------------------------|-------------------------------------|-------------------------------------|-----------------------------------|
|                                              |                           | Specified max length [m] | Attached during test                | Shielded                            | Coupled to patient <sup>(3)</sup> |
|                                              |                           |                          |                                     |                                     |                                   |
|                                              | LTE RF                    | 2                        | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>          |
|                                              | GPS                       | 2                        | <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 checked="" type="checkbox"/> | <input type="checkbox"/> |
|                                                 | <input type="checkbox"/>            | AC:                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |
|                                                 | <input checked="" type="checkbox"/> | DC: 3.0-5.5V, nominal 3.8V     |                          |                          |                          |                                     |                          |
| <input type="checkbox"/>                        | DC:                                 |                                |                          |                          |                          |                                     |                          |
| Rated Power..... :                              | 1W                                  |                                |                          |                          |                          |                                     |                          |
| Clock frequencies..... :                        | 32kHz, 32MHz                        |                                |                          |                          |                          |                                     |                          |
| Other parameters ..... :                        | Temperature range: -40C..+85C       |                                |                          |                          |                          |                                     |                          |
| Software version..... :                         | mfw_nrf91x1_2.0.0                   |                                |                          |                          |                          |                                     |                          |
| Hardware version ..... :                        | nRF9151 LACA AA                     |                                |                          |                          |                          |                                     |                          |
| Dimensions in cm (W x H x D) ... :              | 155x64x9mm                          |                                |                          |                          |                          |                                     |                          |
| 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             |                                     |                          |
|                                                 | -                                   |                                | -                        |                          | -                        |                                     |                          |
| Accessories (not part of the test item) ..... : | Description                         |                                | Type                     |                          | Manufacturer             |                                     |                          |
|                                                 | -                                   |                                | -                        |                          | -                        |                                     |                          |
| Documents as provided by the applicant..... :   | Description                         |                                | File name                |                          | Issue date               |                                     |                          |
|                                                 | -                                   |                                | -                        |                          | -                        |                                     |                          |

<sup>(3)</sup> Only for Medical Equipment

### Identification of the client

NORDIC SEMICONDUCTOR ASA  
Otto Nielsens Veg 12, 7052 Trondheim, Norway

### Testing period and place

|               |                                        |
|---------------|----------------------------------------|
| Test Location | DEKRA Testing and Certification S.A.U. |
| Date (start)  | 2024-01-18                             |
| Date (finish) | 2024-02-22                             |

### Document history

| Report number | Date       | Description    |
|---------------|------------|----------------|
| 77535RRF.003  | 2024-03-21 | First release. |

## Environmental conditions

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

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

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

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

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

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

## Remarks and comments

The tests have been performed by the technical personnel: Antonio Maireles, Rafael Fernández, Pablo Redondo, Carmen Vázquez.

Used instrumentation:

| Control No. | Equipment                                   | Model          | Manufacturer                | Next Calibration |
|-------------|---------------------------------------------|----------------|-----------------------------|------------------|
| 7760        | Digital Multimeter                          | 175            | FLUKE                       | 2024-11          |
| 6157        | Signal and Spectrum Analyzer 10 Hz - 40 GHz | FSV40          | ROHDE AND SCHWARZ           | 2025-01          |
| 9227        | Wideband Radio Communication Tester         | CMW500         | ROHDE AND SCHWARZ           | 2024-07          |
| 6254        | Attenuator 6 dB 2W DC-26.5 GHz              | TWSMAG2        | TECHNIWAVE                  | 2024-03          |
| 6794        | Shielded Room                               | S101           | ETS LINDGREN                | N/A              |
| 8002        | TEMPERATURE CHAMBER MK56 BINDER             | MK 56          | BINDER                      | 2024-04          |
| 6668        | Signal and Spectrum Analyzer 10 Hz - 40 GHz | FSV40          | ROHDE AND SCHWARZ           | 2024-12          |
| 9229        | Wideband Radio Communication Tester         | CMW500         | ROHDE AND SCHWARZ           | 2024-06          |
| 8849        | Wideband Radio Communication Tester         | CMW500         | ROHDE AND SCHWARZ           | 2025-10          |
| 6791        | SEMIANECHOIC ABSORBER LINED                 | FACT 3 200 STP | ETS LINDGREN                | N/A              |
| 6792        | SHIELDED ROOM                               | S101           | ETS LINDGREN                | N/A              |
| 6143        | Biconical/Log Antenna 30 MHz - 6 GHz        | 3142E          | ETS LINDGREN                | 2027-01          |
| 6021        | Attenuator 3 dB, 2W, DC-6GHz                | 50HN-03        | JFW                         | 2025-02          |
| 3783        | PRE-AMPLIFIER G>30dB 1GHz-18GHz             | BLMA 0118-3A   | BONN ELEKTRONIK             | 2025-02          |
| 6496        | HORN ANTENNA 1-18 GHz                       | BBHA 9120 D    | SCHWARZBECK                 | 2026-12          |
| 8856        | PRE-AMPLIFIER G>30dB 18-40GHz               | BLMA 1840-4A   | BONN ELEKTRONIK             | 2025-01          |
| 4657        | Horn Antenna 18-40 GHz                      | BBHA 9170      | SCHWARZBECK MESS-ELEKTRONIK | 2026-06          |
| 4848        | SOFTWARE FOR EMC/RF TESTING                 | EMC32          | ROHDE AND SCHWARZ           | N/A              |

## Testing verdicts

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

## Summary

### Appendix A: LTE Cat-M1 Bands 4, 8, 12, 13, 66, 85.

| FCC PART 27 / RSS-Gen, RSS-130, RSS-139                                                      |         |        |
|----------------------------------------------------------------------------------------------|---------|--------|
| Requirement – Test case                                                                      | Verdict | Remark |
| FCC 27.50 / RSS-130 4.6, RSS-139 5.5: RF Output Power                                        | P       |        |
| FCC 2.1047 / RSS-130 4.2, RSS-139 5.3: Modulation Characteristics                            | P       |        |
| FCC 27.54 / RSS-130 4.5, RSS-139 5.4: Frequency Stability                                    | P       |        |
| FCC 2.1049 / RSS-Gen 6.7: Occupied Bandwidth                                                 | P       |        |
| FCC 27.53 / RSS-130 4.7, RSS-139 5.6: Spurious Emissions at Antenna Terminals                | P       |        |
| FCC 27.53 / RSS-130 4.7, RSS-139 5.6: Spurious Emissions at Antenna Terminals at Block Edges | P       |        |
| FCC 27.53 / RSS-130 4.7, RSS-139 5.6: Radiated Emissions                                     | P       |        |
| <u>Supplementary information and remarks:</u><br>None.                                       |         |        |

### Appendix B: LTE Cat NB1 Bands 4, 8, 12, 13, 17, 66, 85.

| FCC PART 27 / RSS-Gen, RSS-130, RSS-139                                                      |         |        |
|----------------------------------------------------------------------------------------------|---------|--------|
| Requirement – Test case                                                                      | Verdict | Remark |
| FCC 27.50 / RSS-130 4.6, RSS-139 5.5: RF Output Power                                        | P       |        |
| FCC 2.1047 / RSS-130 4.2, RSS-139 5.3: Modulation Characteristics                            | P       |        |
| FCC 27.54 / RSS-130 4.5, RSS-139 5.4: Frequency Stability                                    | P       |        |
| FCC 2.1049 / RSS-Gen 6.7: Occupied Bandwidth                                                 | P       |        |
| FCC 27.53 / RSS-130 4.7, RSS-139 5.6: Spurious Emissions at Antenna Terminals                | P       |        |
| FCC 27.53 / RSS-130 4.7, RSS-139 5.6: Spurious Emissions at Antenna Terminals at Block Edges | P       |        |
| FCC 27.53 / RSS-130 4.7, RSS-139 5.6: Radiated Emissions                                     | P       |        |
| <u>Supplementary information and remarks:</u><br>None.                                       |         |        |

## Appendix A: Test results for FCC 27 / RSS-130, RSS-139: LTE Cat-M1 Bands 4, 8, 12, 13, 66, 85

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TEST CONDITIONS

(\*): Declared by the Applicant.

POWER SUPPLY (\*):

Vnormal: 3.8 Vdc.  
Vminimum: 3 Vdc  
Vmaximum: 5.5 Vdc  
Type of Power Supply: Internal DC.

ANTENNA (\*):

| Low Bands     | Gain (dBi) | Type of Antenna |
|---------------|------------|-----------------|
| LTE Cat-M1 8  | +2.70      | SMD             |
| LTE Cat-M1 12 | +1.56      | SMD             |
| LTE Cat-M1 13 | +1.56      | SMD             |
| LTE Cat-M1 85 | +1.56      | SMD             |
| High Bands    | Gain (dBi) | Type            |
| LTE Cat-M1 4  | +3.0       | SMD             |
| LTE Cat-M1 66 | +3.0       | SMD             |

TEST FREQUENCIES:

LTE Cat-M1 Band 4. QPSK and 16QAM modulations:

|        | Channel per BW=(Frequency, MHz) |                   |                   |                   |                   |                   |
|--------|---------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
|        | BW = 1.4 MHz                    | BW = 3 MHz        | BW = 5 MHz        | BW = 10 MHz       | BW = 15 MHz       | BW = 20 MHz       |
| Low    | 19957<br>(1710.7)               | 19965<br>(1711.5) | 19975<br>(1712.5) | 20000<br>(1715.0) | 20025<br>(1717.5) | 20050<br>(1720.0) |
| Middle | 20175<br>(1732.5)               | 20175<br>(1732.5) | 20175<br>(1732.5) | 20175<br>(1732.5) | 20175<br>(1732.5) | 20175<br>(1732.5) |
| High   | 20393<br>(1754.3)               | 20385<br>(1753.5) | 20375<br>(1752.5) | 20350<br>(1750.0) | 20325<br>(1747.5) | 20300<br>(1745.0) |

NOTE: LTE Cat-M1 Band 4 is completely included in LTE Cat-M1 Band 66, so the channels of LTE Cat-M1 Band 66 were tested to give conformity to the assigned block.

LTE Cat-M1 Band 8. QPSK and 16QAM modulations:

|        | Channel (Frequency, MHz) |                |
|--------|--------------------------|----------------|
|        | BW = 1.4 MHz             | BW = 3 MHz     |
| Low    | 21632<br>(898.2)         |                |
| Middle |                          | 21640<br>(899) |
| High   | 21648<br>(899.8)         |                |

LTE Cat-M1 Band 12. QPSK and 16QAM modulations:

|        | Channel (Frequency, MHz) |                  |                  |                  |
|--------|--------------------------|------------------|------------------|------------------|
|        | BW = 1.4 MHz             | BW = 3 MHz       | BW = 5 MHz       | BW = 10 MHz      |
| Low    | 23017<br>(699.7)         | 23025<br>(700.5) | 23035<br>(701.5) | 23060<br>(704.0) |
| Middle | 23095<br>(707.5)         | 23095<br>(707.5) | 23095<br>(707.5) | 23095<br>(707.5) |
| High   | 23173<br>(715.3)         | 23165<br>(714.5) | 23155<br>(713.5) | 23130<br>(711.0) |

NOTE: LTE Cat-M1 Band 12 is completely included in LTE Cat-M1 Band 85, so the channels of LTE Cat-M1 Band 85 were tested to give conformity to the assigned block, but for the Block Edge test, where only the Low Channel was tested for 85.

LTE Cat-M1 Band 13. QPSK and 16QAM modulations:

|        | Channel (Frequency, MHz) |                  |
|--------|--------------------------|------------------|
|        | BW = 5 MHz               | BW = 10 MHz      |
| Low    | 23205<br>(779.5)         |                  |
| Middle | 23230<br>(782.0)         | 23230<br>(782.0) |
| High   | 23255<br>(784.5)         |                  |

LTE Cat-M1 Band 66. QPSK and 16QAM modulations:

|        | Channel per BW=(Frequency, MHz) |                    |                    |                    |                    |                    |
|--------|---------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|        | BW = 1.4 MHz                    | BW = 3 MHz         | BW = 5 MHz         | BW = 10 MHz        | BW = 15 MHz        | BW = 20 MHz        |
| Low    | 131979<br>(1710.7)              | 131987<br>(1711.5) | 131997<br>(1712.5) | 132022<br>(1715.0) | 132047<br>(1717.5) | 132072<br>(1720.0) |
| Middle | 132322<br>(1745)                | 132322<br>(1745)   | 132322<br>(1745)   | 132322<br>(1745)   | 132322<br>(1745)   | 132322<br>(1745)   |
| High   | 132665<br>(1779.3)              | 132657<br>(1778.5) | 132647<br>(1777.5) | 132622<br>(1775)   | 132597<br>(1772.5) | 132572<br>(1770)   |

LTE Cat-M1 Band 85. QPSK and 16QAM modulations:

|        | Channel (Frequency) |                   |
|--------|---------------------|-------------------|
|        | BW = 5 MHz          | BW = 10 MHz       |
| Low    | 134027<br>(700.5)   | 134052<br>(703.0) |
| Middle | 134092<br>(707)     | 134092<br>(707)   |
| High   | 134157<br>(713.5)   | 134132<br>(711.0) |

## RF Output Power

### Limits

#### 1. LTE Cat-M1 Band 8. FCC §27.1507 (a) & (d).

FCC §27.1507 (a) & (d):

(a) *Maximum ERP*. The power limits specified in this section are applicable to operations in areas more than 110 km (68.4 miles) from the U.S./Mexico border and 140 km (87 miles) from the U.S./Canada border.

(3) *Mobile, control and auxiliary test stations*. Mobile, control and auxiliary test stations must not exceed 10 watts ERP.

(4) *Portable stations*. Portable stations must not exceed 3 watts ERP.

(d) *PAR limit*. The peak-to-average ratio (PAR) of the transmission must not exceed 13 dB.

#### 2. LTE Cat-M1 Band 13. FCC §27.50 (b) (10) / RSS-130 Clause 4.6.

FCC §27.50 (b) (10):

Portable stations (hand-held devices) transmitting in the 746-757 MHz, 776-788 MHz, and 805-806 MHz bands are limited to 3 watts ERP.

RSS-130 4.6:

##### 4.6.1 General

The transmitter output power shall be measured in terms of average 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 and shall use a signal corresponding to the High PAPR during periods of continuous transmission.

##### 4.6.3 Frequency bands 698-756 MHz and 777-787 MHz

The e.r.p. shall not exceed 30 watts for mobile equipment and outdoor fixed subscriber equipment. The e.r.p. shall not exceed 3 watts for portable equipment and indoor fixed subscriber equipment.

#### 3. LTE Cat-M1 Band 66. FCC §27.50 (d) / RSS-139 5.5.

FCC §27.50 (d):

(4) Fixed, mobile, and portable (hand-held) stations operating in the 1710-1755 MHz band and mobile and portable stations operating in the 1695-1710 MHz and 1755-1780 MHz bands are limited to 1 watt EIRP. Fixed stations operating in the 1710-1755 MHz band are limited to a maximum antenna height of 10 meters above ground. Mobile and portable stations operating in these bands must employ a means for limiting power to the minimum necessary for successful communications.

(5) 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-139 5.5:

The maximum output power of the equipment shall comply with the limits specified below. In the tables, maximum power refers to the equivalent isotropically radiated power (e.i.r.p.) or total radiated power (TRP), measured in terms of average values.

The limits in this RSS are specified for the purpose of certification and may not apply to all deployment scenarios. Consult SRSP-513 and SRSP-519 for more details on the bands 2110-2180 MHz and 2180-2200 MHz respectively.

| Table 3: Maximum power of equipment in the band 1710-1780 MHz |                                   |
|---------------------------------------------------------------|-----------------------------------|
| Equipment type                                                | Maximum power                     |
| Fixed station and base station                                | 30 dBm e.i.r.p./channel bandwidth |
| Subscriber equipment                                          | 30 dBm e.i.r.p./channel bandwidth |

| Table 4: Maximum power of equipment in the band 2110-2180 MHz |                                   |
|---------------------------------------------------------------|-----------------------------------|
| Equipment type                                                | Maximum power                     |
| Non-AAS fixed station and base station                        | 65 dBm e.i.r.p./MHz               |
| AAS fixed station and base station                            | 46 dBm TRP/MHz                    |
| Subscriber equipment                                          | 30 dBm e.i.r.p./channel bandwidth |

| Table 5: Maximum power of equipment in the band 2180-2200 MHz |                     |
|---------------------------------------------------------------|---------------------|
| Equipment type                                                | Maximum power       |
| Non-AAS base station                                          | 65 dBm e.i.r.p./MHz |
| AAS base station                                              | 46 dBm TRP/MHz      |

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

#### 4. LTE Cat-M1 Band 12, 85. FCC §27.50 (c) (10) / RSS-130 Clause 4.6.

FCC §27.50 (c) (10):

Portable stations (hand-held devices) in the 600 MHz uplink band and the 698-746 MHz band, and fixed and mobile stations in the 600 MHz uplink band are limited to 3 watts ERP.

RSS-130 Clause 4.6:

##### 4.6.1 General

The transmitter output power shall be measured in terms of average 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 and shall use a signal corresponding to the High PAPR during periods of continuous transmission.

##### 4.6.3 Frequency bands 698-756 MHz and 777-787 MHz

The e.r.p. shall not exceed 30 watts for mobile equipment and outdoor fixed subscriber equipment. The e.r.p. shall not exceed 3 watts for portable equipment and indoor fixed subscriber equipment.

#### 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 CMW500, selecting maximum transmission power of the EUT and different modes of modulation.

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 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:

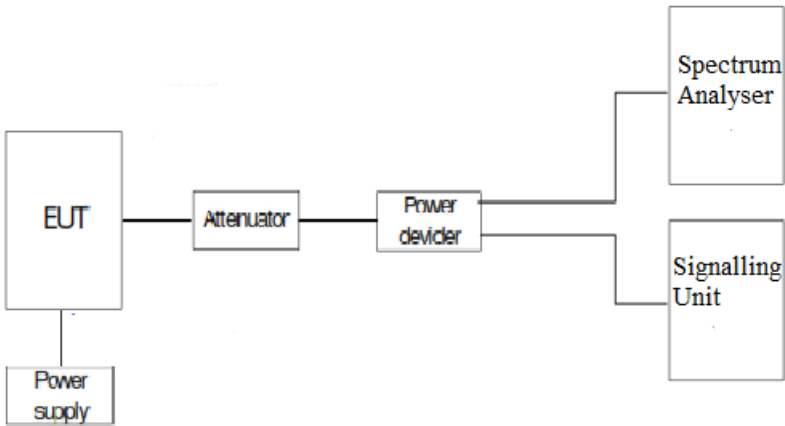
$$E.R.P. = E.I.R.P. - 2.15 \text{ dB}$$

Test Setup

1. CONDUCTED AVERAGE POWER:



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



Results

1. CONDUCTED AVERAGE POWER:

LTE Cat-M1 Band 8:

Worst-case of RF Power is BW=1.4 MHz, High Channel, QPSK, RB Size=1, RB Offset=2, Narrowband=0.

| BANDWIDTH<br>(MHz) | CHANNEL       | FREQUENCY<br>(MHz) | MODULATION | RB SIZE | RB<br>OFFSET | AVERAGE<br>POWER<br>(dBm) |
|--------------------|---------------|--------------------|------------|---------|--------------|---------------------------|
| 1.4                | Low<br>21632  | 898.2              | QPSK       | 1       | 0            | 22.77                     |
|                    |               |                    |            | 1       | 2            | 22.81                     |
|                    |               |                    |            | 1       | 5            | 22.77                     |
|                    |               |                    |            | 3       | 0            | 21.75                     |
|                    |               |                    |            | 3       | 1            | 21.71                     |
|                    |               |                    |            | 3       | 3            | 21.75                     |
|                    |               |                    |            | 6       | 0            | 21.93                     |
|                    |               |                    | 16QAM      | 1       | 0            | 22.51                     |
|                    |               |                    |            | 1       | 2            | 22.61                     |
|                    |               |                    |            | 1       | 5            | 22.66                     |
|                    |               |                    |            | 3       | 0            | 21.52                     |
|                    |               |                    |            | 3       | 1            | 21.58                     |
|                    |               |                    |            | 3       | 3            | 21.53                     |
|                    |               |                    |            | 5       | 0            | 20.45                     |
|                    | High<br>21648 | 899.8              | QPSK       | 1       | 0            | 22.8                      |
|                    |               |                    |            | 1       | 2            | 22.92                     |
|                    |               |                    |            | 1       | 5            | 22.8                      |
|                    |               |                    |            | 3       | 0            | 21.78                     |
|                    |               |                    |            | 3       | 1            | 21.74                     |
|                    |               |                    |            | 3       | 3            | 21.77                     |
|                    |               |                    |            | 6       | 0            | 20.08                     |
|                    |               |                    | 16QAM      | 1       | 0            | 22.56                     |
|                    |               |                    |            | 1       | 2            | 22.56                     |
|                    |               |                    |            | 1       | 5            | 22.55                     |
|                    |               |                    |            | 3       | 0            | 21.56                     |
|                    |               |                    |            | 3       | 1            | 21.52                     |
|                    |               |                    |            | 3       | 3            | 21.56                     |
|                    |               |                    |            | 5       | 0            | 20.49                     |

BW=1.4 MHz. QPSK:

| MAX<br>POWER | QPSK<br>COND.<br>POWER<br>AVG (dBm) | ANTENNA<br>GAIN (dBi) | RAD.<br>POWER<br>AVG EIRP<br>(dBm) | RAD.<br>POWER<br>AVG ERP<br>(dBm) |
|--------------|-------------------------------------|-----------------------|------------------------------------|-----------------------------------|
| LOW          | 22.81                               | 2.7                   | 25.51                              | 23.36                             |
| MIDDLE       |                                     |                       |                                    |                                   |
| HIGH         | 22.92                               | 2.7                   | 25.62                              | 23.47                             |
| MAX:         | 22.92                               |                       | 25.62                              | 23.47                             |

BW=1.4 MHz. 16QAM:

| MAX<br>POWER | 16QAM<br>COND.<br>POWER<br>AVG (dBm) | ANTENNA<br>GAIN (dBi) | RAD.<br>POWER<br>AVG EIRP<br>(dBm) | RAD.<br>POWER<br>AVG ERP<br>(dBm) |
|--------------|--------------------------------------|-----------------------|------------------------------------|-----------------------------------|
| LOW          | 22.66                                | 2.7                   | 25.36                              | 23.21                             |
| MIDDLE       |                                      |                       |                                    |                                   |
| HIGH         | 22.56                                | 2.7                   | 25.26                              | 23.11                             |
| MAX:         | 22.66                                |                       | 25.36                              | 23.21                             |

LTE Cat-M1 Band 13:

Worst-case of RF Power is BW=5 MHz. High Channel. QPSK. RB Size=1. RB Offset=0. Narrowband=0.

| BANDWIDTH<br>(MHz) | CHANNEL       | FREQUENCY<br>(MHz) | MODULATION | RB SIZE | RB<br>OFFSET | AVERAGE<br>POWER<br>(dBm) |
|--------------------|---------------|--------------------|------------|---------|--------------|---------------------------|
| 5                  | Low<br>23205  | 779.5              | QPSK       | 1       | 0            | 22.11                     |
|                    |               |                    |            | 1       | 2            | 22.11                     |
|                    |               |                    |            | 1       | 5            | 22.11                     |
|                    |               |                    |            | 3       | 0            | 21.11                     |
|                    |               |                    |            | 3       | 1            | 21.11                     |
|                    |               |                    |            | 3       | 3            | 21.10                     |
|                    |               |                    |            | 6       | 0            | 21.20                     |
|                    |               |                    | 16QAM      | 1       | 0            | 21.55                     |
|                    |               |                    |            | 1       | 2            | 21.39                     |
|                    |               |                    |            | 1       | 5            | 21.41                     |
|                    |               |                    |            | 3       | 0            | 20.89                     |
|                    | High<br>23255 | 784.5              | QPSK       | 3       | 1            | 20.88                     |
|                    |               |                    |            | 3       | 3            | 20.89                     |
|                    |               |                    |            | 5       | 0            | 20.01                     |
|                    |               |                    |            | 1       | 0            | 22.14                     |
|                    |               |                    |            | 1       | 2            | 22.13                     |
|                    |               |                    |            | 1       | 5            | 22.14                     |
|                    |               |                    |            | 3       | 0            | 21.23                     |
|                    |               |                    |            | 3       | 1            | 21.24                     |
|                    |               |                    |            | 3       | 3            | 21.22                     |
|                    |               |                    |            | 6       | 0            | 21.25                     |
|                    |               |                    | 16QAM      | 1       | 0            | 22.06                     |
|                    |               |                    |            | 1       | 2            | 22.05                     |
|                    |               |                    |            | 1       | 5            | 22.06                     |
|                    |               |                    |            | 3       | 0            | 20.98                     |
|                    |               |                    |            | 3       | 1            | 20.99                     |
|                    |               |                    |            | 3       | 3            | 21                        |
|                    |               |                    |            | 5       | 0            | 20                        |

BW=5 MHz. QPSK:

| MAX<br>POWER | QPSK<br>COND.<br>POWER<br>AVG (dBm) | ANTENNA<br>GAIN (dBi) | RAD.<br>POWER<br>AVG EIRP<br>(dBm) | RAD.<br>POWER<br>AVG ERP<br>(dBm) |
|--------------|-------------------------------------|-----------------------|------------------------------------|-----------------------------------|
| LOW          | 22.11                               | 1.56                  | 23.67                              | 21.52                             |
| MIDDLE       |                                     |                       |                                    |                                   |
| HIGH         | 22.14                               | 1.56                  | 23.7                               | 21.55                             |
| MAX:         | 22.14                               |                       | 23.7                               | 21.55                             |

BW=5 MHz. 16QAM:

| MAX<br>POWER | 16QAM<br>COND.<br>POWER<br>AVG (dBm) | ANTENNA<br>GAIN (dBi) | RAD.<br>POWER<br>AVG EIRP<br>(dBm) | RAD.<br>POWER<br>AVG ERP<br>(dBm) |
|--------------|--------------------------------------|-----------------------|------------------------------------|-----------------------------------|
| LOW          | 21.55                                | 1.56                  | 23.11                              | 20.96                             |
| MIDDLE       |                                      |                       |                                    |                                   |
| HIGH         | 22.06                                | 1.56                  | 23.62                              | 21.47                             |
| MAX:         | 22.06                                |                       | 23.62                              | 21.47                             |

LTE Cat-M1 Band 66:

Worst-case of RF Power is BW=15 MHz. Low Channel. QPSK. RB Size=6. RB Offset=0. Narrowband=0.

| BANDWIDTH<br>(MHz) | CHANNEL          | FREQUENCY<br>(MHz) | MODULATION | RB SIZE | RB<br>OFFSET | AVERAGE<br>POWER<br>(dBm) |
|--------------------|------------------|--------------------|------------|---------|--------------|---------------------------|
| 15                 | Low<br>132047    | 1717.5             | QPSK       | 1       | 0            | 22.68                     |
|                    |                  |                    |            | 1       | 2            | 22.81                     |
|                    |                  |                    |            | 1       | 5            | 22.68                     |
|                    |                  |                    |            | 3       | 0            | 22.74                     |
|                    |                  |                    |            | 3       | 1            | 22.71                     |
|                    |                  |                    |            | 3       | 3            | 22.75                     |
|                    |                  |                    |            | 6       | 0            | 22.87                     |
|                    |                  |                    | 16QAM      | 1       | 0            | 22.78                     |
|                    |                  |                    |            | 1       | 2            | 22.83                     |
|                    |                  |                    |            | 1       | 5            | 22.79                     |
|                    |                  |                    |            | 3       | 0            | 22.83                     |
|                    |                  |                    |            | 3       | 1            | 22.8                      |
|                    |                  |                    |            | 3       | 3            | 22.78                     |
|                    |                  |                    |            | 5       | 0            | 22.69                     |
|                    | Middle<br>132322 | 1745               | QPSK       | 1       | 0            | 22.55                     |
|                    |                  |                    |            | 1       | 2            | 22.64                     |
|                    |                  |                    |            | 1       | 5            | 22.57                     |
|                    |                  |                    |            | 3       | 0            | 22.48                     |
|                    |                  |                    |            | 3       | 1            | 22.45                     |
|                    |                  |                    |            | 3       | 3            | 22.5                      |
|                    |                  |                    |            | 6       | 0            | 22.6                      |
|                    |                  |                    | 16QAM      | 1       | 0            | 22.5                      |
|                    |                  |                    |            | 1       | 2            | 22.53                     |
|                    |                  |                    |            | 1       | 5            | 22.4                      |
|                    |                  |                    |            | 3       | 0            | 22.67                     |
|                    |                  |                    |            | 3       | 1            | 22.66                     |
|                    |                  |                    |            | 3       | 3            | 22.6                      |
|                    |                  |                    |            | 5       | 0            | 22.5                      |
|                    | High<br>132597   | 1772.5             | QPSK       | 1       | 0            | 22.71                     |
|                    |                  |                    |            | 1       | 2            | 22.83                     |
|                    |                  |                    |            | 1       | 5            | 22.69                     |
|                    |                  |                    |            | 3       | 0            | 22.8                      |
|                    |                  |                    |            | 3       | 1            | 22.66                     |
|                    |                  |                    |            | 3       | 3            | 22.8                      |
|                    |                  |                    |            | 6       | 0            | 22.7                      |
|                    |                  |                    | 16QAM      | 1       | 0            | 22.3                      |
|                    |                  |                    |            | 1       | 2            | 22.44                     |
|                    |                  |                    |            | 1       | 5            | 22.17                     |
|                    |                  |                    |            | 3       | 0            | 22.58                     |
|                    |                  |                    |            | 3       | 1            | 22.79                     |
|                    |                  |                    |            | 3       | 3            | 22.55                     |
|                    |                  |                    |            | 5       | 0            | 22.67                     |

BW=15 MHz. QPSK:

| MAX<br>POWER | QPSK<br>COND.<br>POWER<br>AVG (dBm) | ANTENNA<br>GAIN (dBi) | RAD.<br>POWER<br>AVG EIRP<br>(dBm) | RAD.<br>POWER<br>AVG ERP<br>(dBm) |
|--------------|-------------------------------------|-----------------------|------------------------------------|-----------------------------------|
| LOW          | 22.87                               | 3                     | 25.87                              | 23.72                             |
| MIDDLE       | 22.64                               | 3                     | 25.64                              | 23.49                             |
| HIGH         | 22.83                               | 3                     | 25.83                              | 23.68                             |
| MAX:         | 22.87                               |                       | 25.87                              | 23.72                             |

BW=15 MHz. 16QAM:

| MAX<br>POWER | 16QAM<br>COND.<br>POWER<br>AVG (dBm) | ANTENNA<br>GAIN (dBi) | RAD.<br>POWER<br>AVG EIRP<br>(dBm) | RAD.<br>POWER<br>AVG ERP<br>(dBm) |
|--------------|--------------------------------------|-----------------------|------------------------------------|-----------------------------------|
| LOW          | 22.83                                | 3                     | 25.83                              | 23.68                             |
| MIDDLE       | 22.67                                | 3                     | 25.67                              | 23.52                             |
| HIGH         | 22.79                                | 3                     | 25.79                              | 23.64                             |
| MAX:         | 22.83                                |                       | 25.83                              | 23.68                             |

LTE Cat-M1 Band 85:

Worst-case of RF Power is BW=5 MHz. High Channel. QPSK. RB Size=1. RB Offset=2. Narrowband=1.

| BANDWIDTH<br>(MHz) | CHANNEL          | FREQUENCY<br>(MHz) | MODULATION | RB SIZE | RB<br>OFFSET | AVERAGE<br>POWER<br>(dBm) |
|--------------------|------------------|--------------------|------------|---------|--------------|---------------------------|
| 5                  | Low<br>134027    | 700.5              | QPSK       | 1       | 0            | 22.81                     |
|                    |                  |                    |            | 1       | 2            | 22.87                     |
|                    |                  |                    |            | 1       | 5            | 22.74                     |
|                    |                  |                    |            | 3       | 0            | 21.76                     |
|                    |                  |                    |            | 3       | 1            | 21.73                     |
|                    |                  |                    |            | 3       | 3            | 21.88                     |
|                    |                  |                    |            | 6       | 0            | 22                        |
|                    |                  |                    | 16QAM      | 1       | 0            | 22.57                     |
|                    |                  |                    |            | 1       | 2            | 22.56                     |
|                    |                  |                    |            | 1       | 5            | 22.57                     |
|                    |                  |                    |            | 3       | 0            | 21.53                     |
|                    |                  |                    |            | 3       | 1            | 21.58                     |
|                    |                  |                    |            | 3       | 3            | 21.61                     |
|                    |                  |                    |            | 5       | 0            | 20.47                     |
|                    | Middle<br>134092 | 707                | QPSK       | 1       | 0            | 22.71                     |
|                    |                  |                    |            | 1       | 2            | 22.85                     |
|                    |                  |                    |            | 1       | 5            | 22.72                     |
|                    |                  |                    |            | 3       | 0            | 21.76                     |
|                    |                  |                    |            | 3       | 1            | 21.73                     |
|                    |                  |                    |            | 3       | 3            | 21.77                     |
|                    |                  |                    |            | 6       | 0            | 21.92                     |
|                    |                  |                    | 16QAM      | 1       | 0            | 22.66                     |
|                    |                  |                    |            | 1       | 2            | 22.61                     |
|                    |                  |                    |            | 1       | 5            | 22.55                     |
|                    |                  |                    |            | 3       | 0            | 21.51                     |
|                    |                  |                    |            | 3       | 1            | 21.58                     |
|                    |                  |                    |            | 3       | 3            | 21.63                     |
|                    |                  |                    |            | 5       | 0            | 20.44                     |
|                    | High<br>134157   | 713.5              | QPSK       | 1       | 0            | 22.8                      |
|                    |                  |                    |            | 1       | 2            | 23.01                     |
|                    |                  |                    |            | 1       | 5            | 22.85                     |
|                    |                  |                    |            | 3       | 0            | 22.01                     |
|                    |                  |                    |            | 3       | 1            | 21.97                     |
|                    |                  |                    |            | 3       | 3            | 21.99                     |
|                    |                  |                    |            | 6       | 0            | 21.92                     |
|                    |                  |                    | 16QAM      | 1       | 0            | 22.38                     |
|                    |                  |                    |            | 1       | 2            | 22.52                     |
|                    |                  |                    |            | 1       | 5            | 22.41                     |
|                    |                  |                    |            | 3       | 0            | 21.68                     |
|                    |                  |                    |            | 3       | 1            | 21.59                     |
|                    |                  |                    |            | 3       | 3            | 21.65                     |
|                    |                  |                    |            | 5       | 0            | 20.53                     |

BW=5 MHz. QPSK:

| MAX<br>POWER | QPSK<br>COND.<br>POWER<br>AVG (dBm) | ANTENNA<br>GAIN (dBi) | RAD.<br>POWER<br>AVG EIRP<br>(dBm) | RAD.<br>POWER<br>AVG ERP<br>(dBm) |
|--------------|-------------------------------------|-----------------------|------------------------------------|-----------------------------------|
| LOW          | 22.87                               | 1.56                  | 24.43                              | 22.28                             |
| MIDDLE       | 22.85                               | 1.56                  | 24.41                              | 22.26                             |
| HIGH         | 23.01                               | 1.56                  | 24.57                              | 22.42                             |
| MAX:         | 23.01                               |                       | 24.57                              | 22.42                             |

BW=5 MHz. 16QAM:

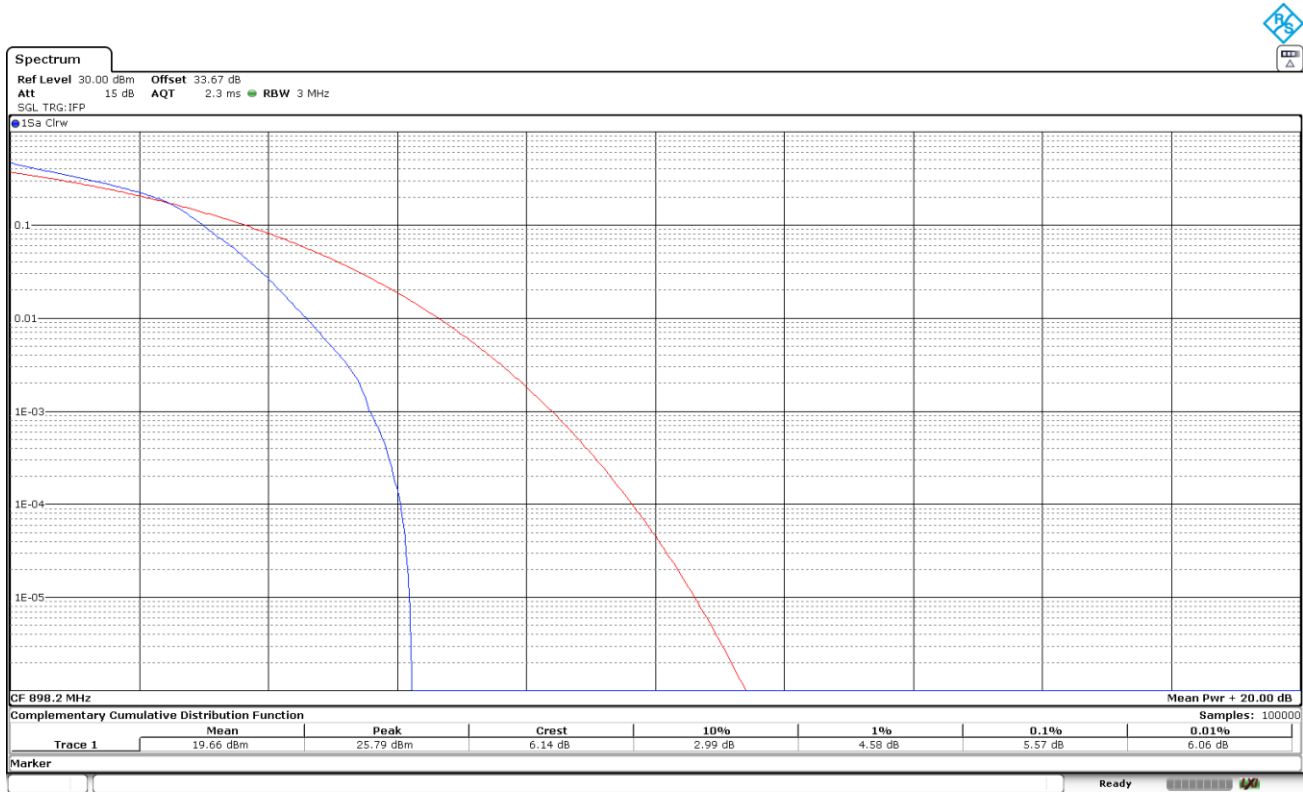
| MAX<br>POWER | 16QAM<br>COND.<br>POWER<br>AVG (dBm) | ANTENNA<br>GAIN (dBi) | RAD.<br>POWER<br>AVG EIRP<br>(dBm) | RAD.<br>POWER<br>AVG ERP<br>(dBm) |
|--------------|--------------------------------------|-----------------------|------------------------------------|-----------------------------------|
| LOW          | 22.57                                | 1.56                  | 24.13                              | 21.98                             |
| MIDDLE       | 22.66                                | 1.56                  | 24.22                              | 22.07                             |
| HIGH         | 22.52                                | 1.56                  | 24.08                              | 21.93                             |
| MAX:         | 22.66                                |                       | 24.22                              | 22.07                             |

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

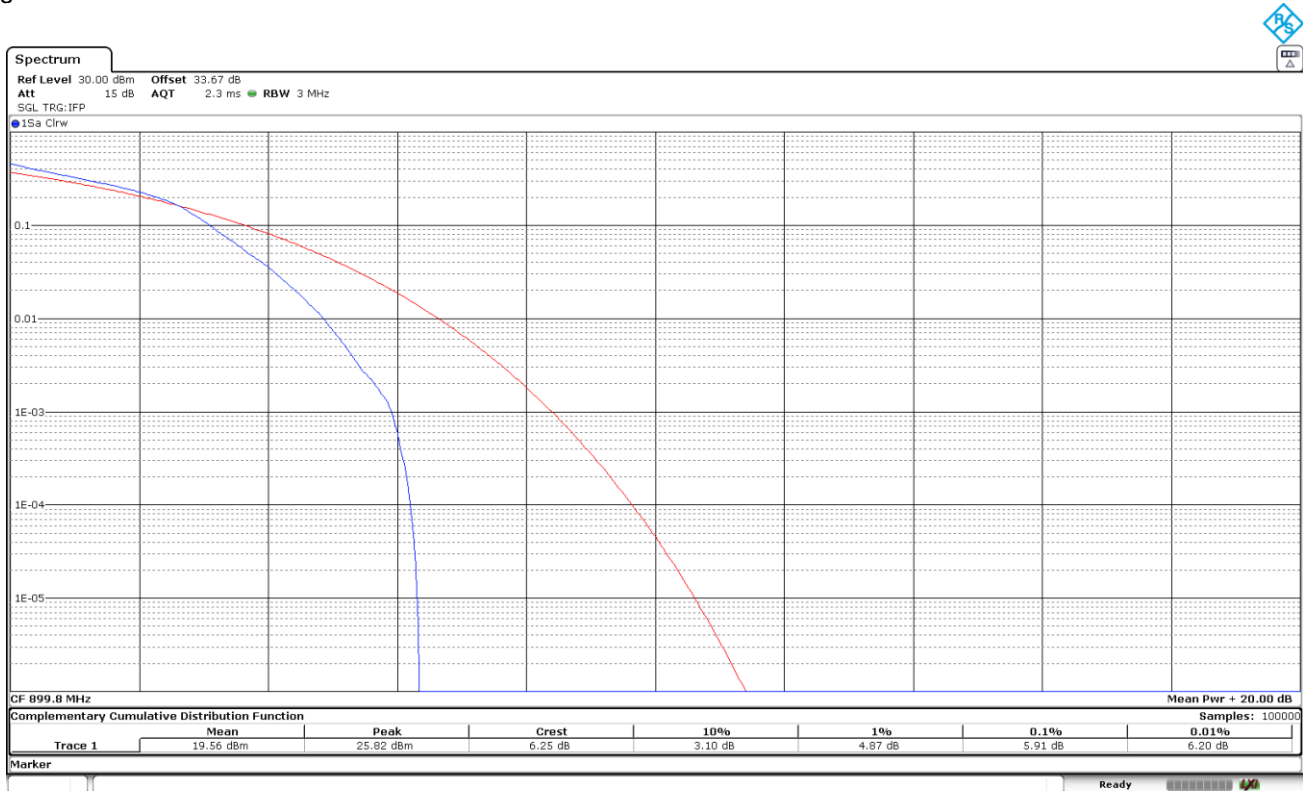
LTE Cat-M1 Band 8:

Worst-case of PAPR is BW=1.4 MHz. High Channel. 16QAM. RB Size=5. RB Offset=0. Narrowband=0.

Low Channel:



High Channel:



|           |      |      |
|-----------|------|------|
| 16QAM     | Low  | High |
| PAPR (dB) | 5.57 | 5.91 |

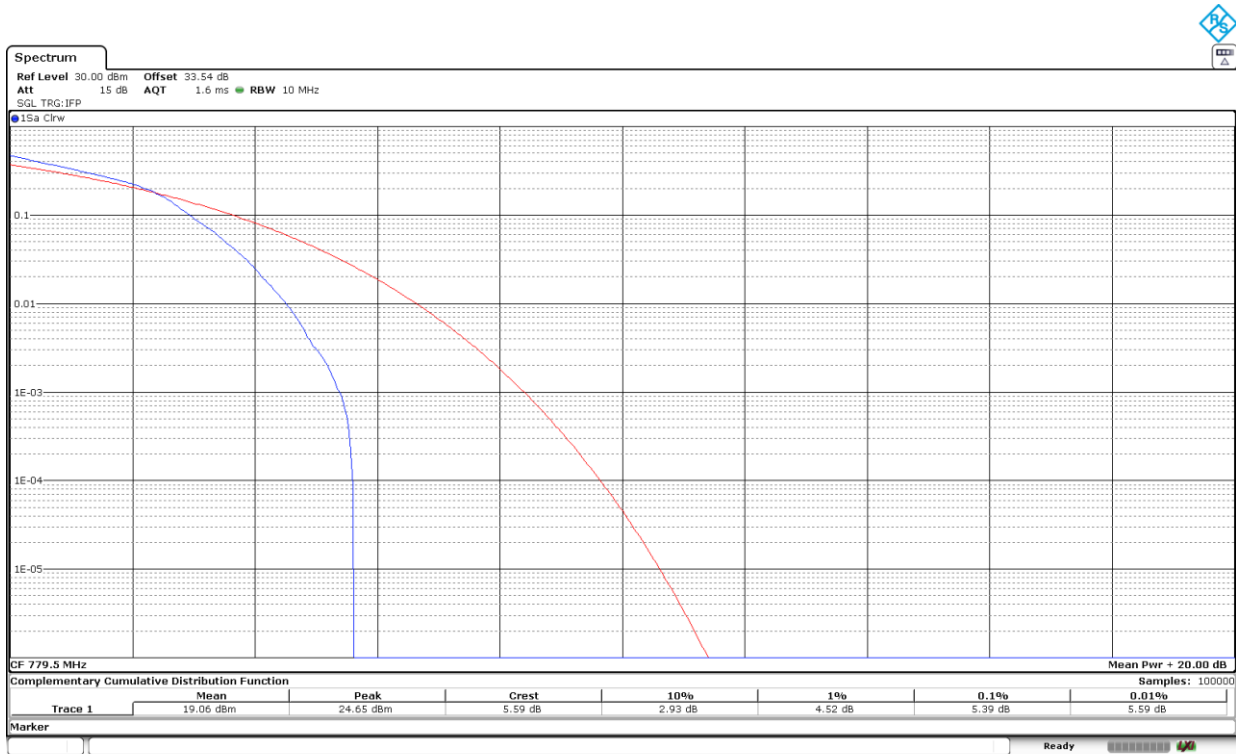
**Verdict**

Pass

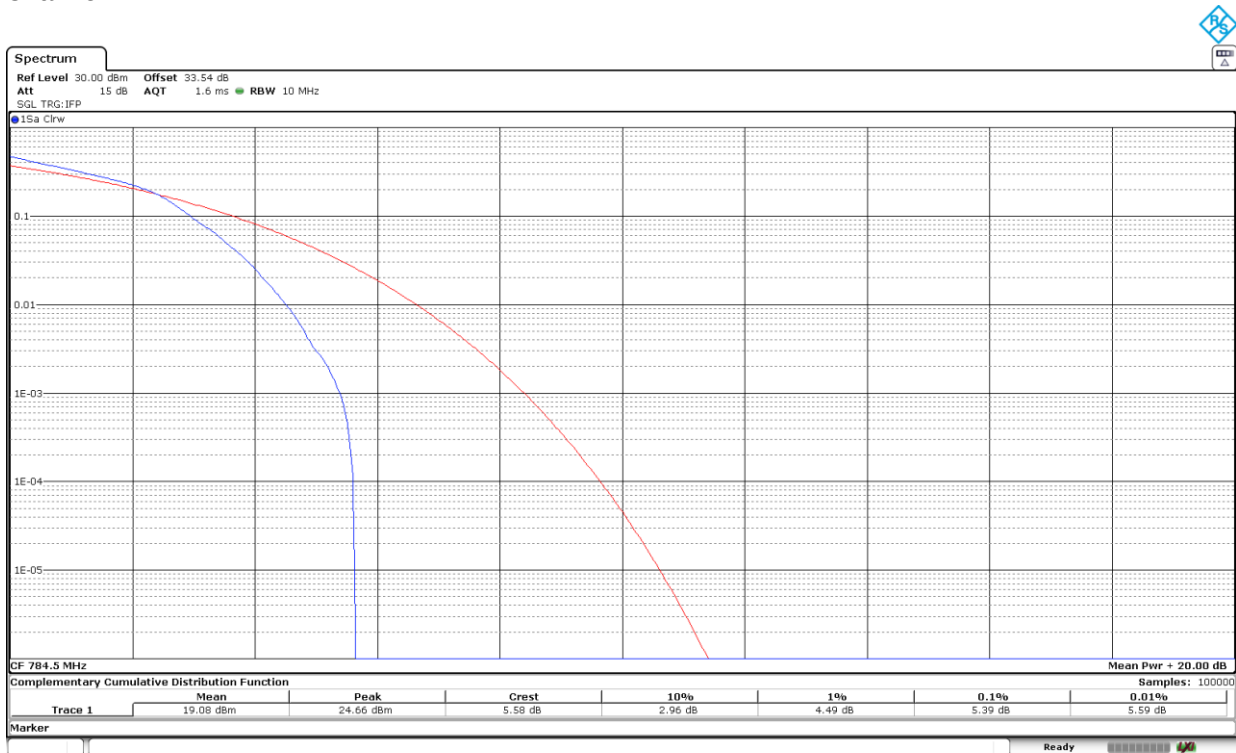
LTE Cat-M1 Band 13:

Worst-case of PAPR is BW= 5 MHz. Low Channel. 16QAM. RB Size=5. RB Offset=0. Narrowband=0.

Low Channel:



High Channel:



|           |      |      |
|-----------|------|------|
| 16QAM     | Low  | High |
| PAPR (dB) | 5.39 | 5.39 |

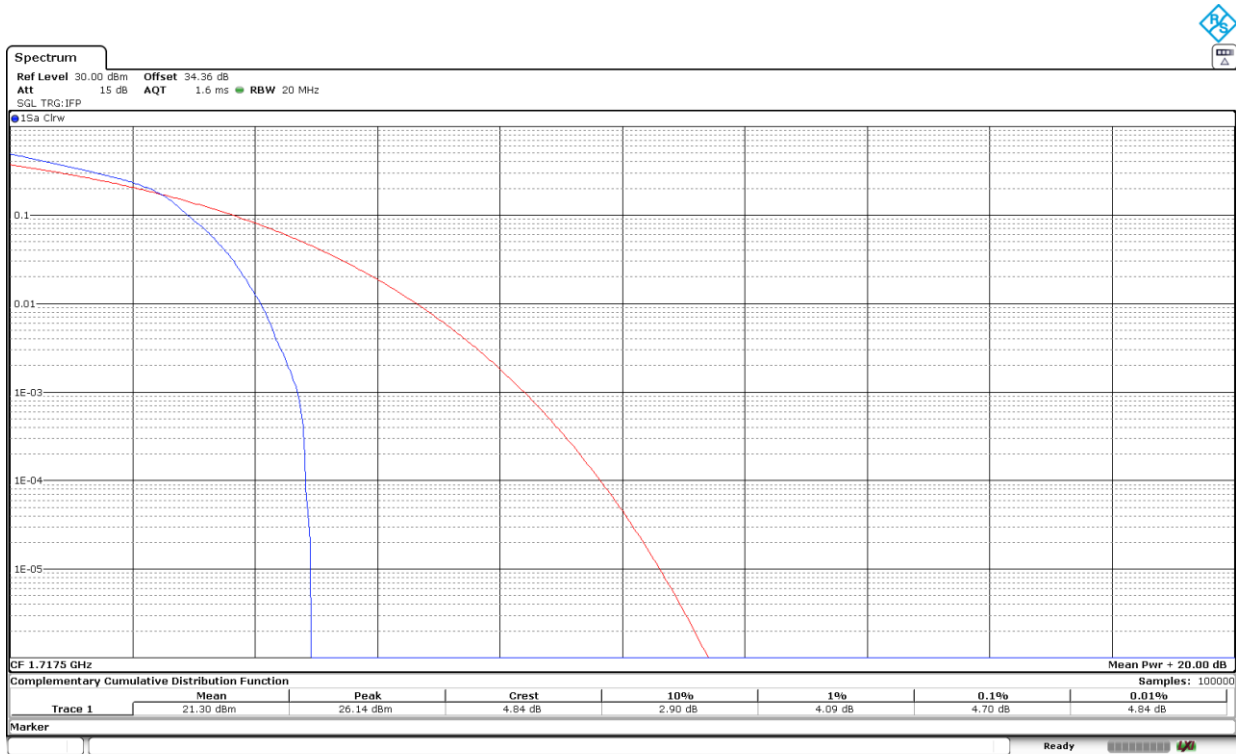
**Verdict**

Pass

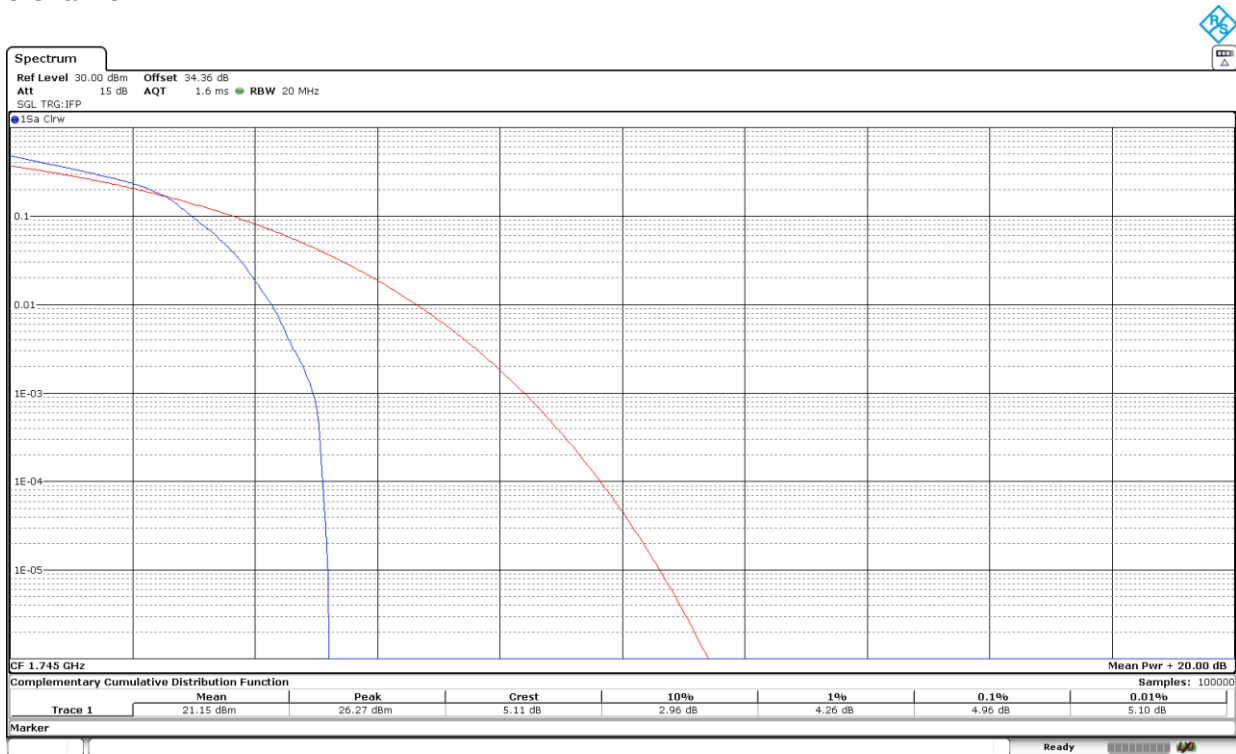
LTE Cat-M1 Band 66:

Worst-case of PAPR is BW= 15 MHz. Middle Channel. 16QAM. RB Size=5. RB Offset=0. Narrowband=0.

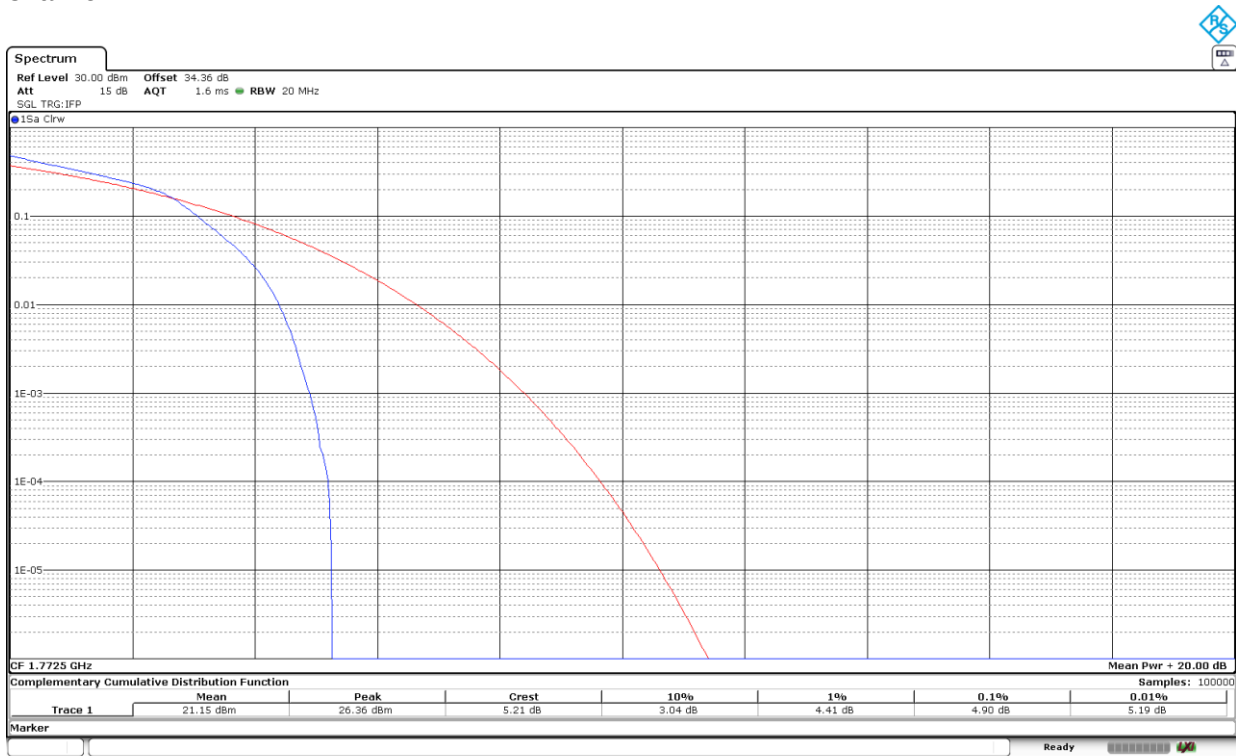
Low Channel:



Middle Channel:



High Channel:



|           |     |        |      |
|-----------|-----|--------|------|
| 16QAM     | Low | Middle | High |
| PAPR (dB) | 4.7 | 4.96   | 4.9  |

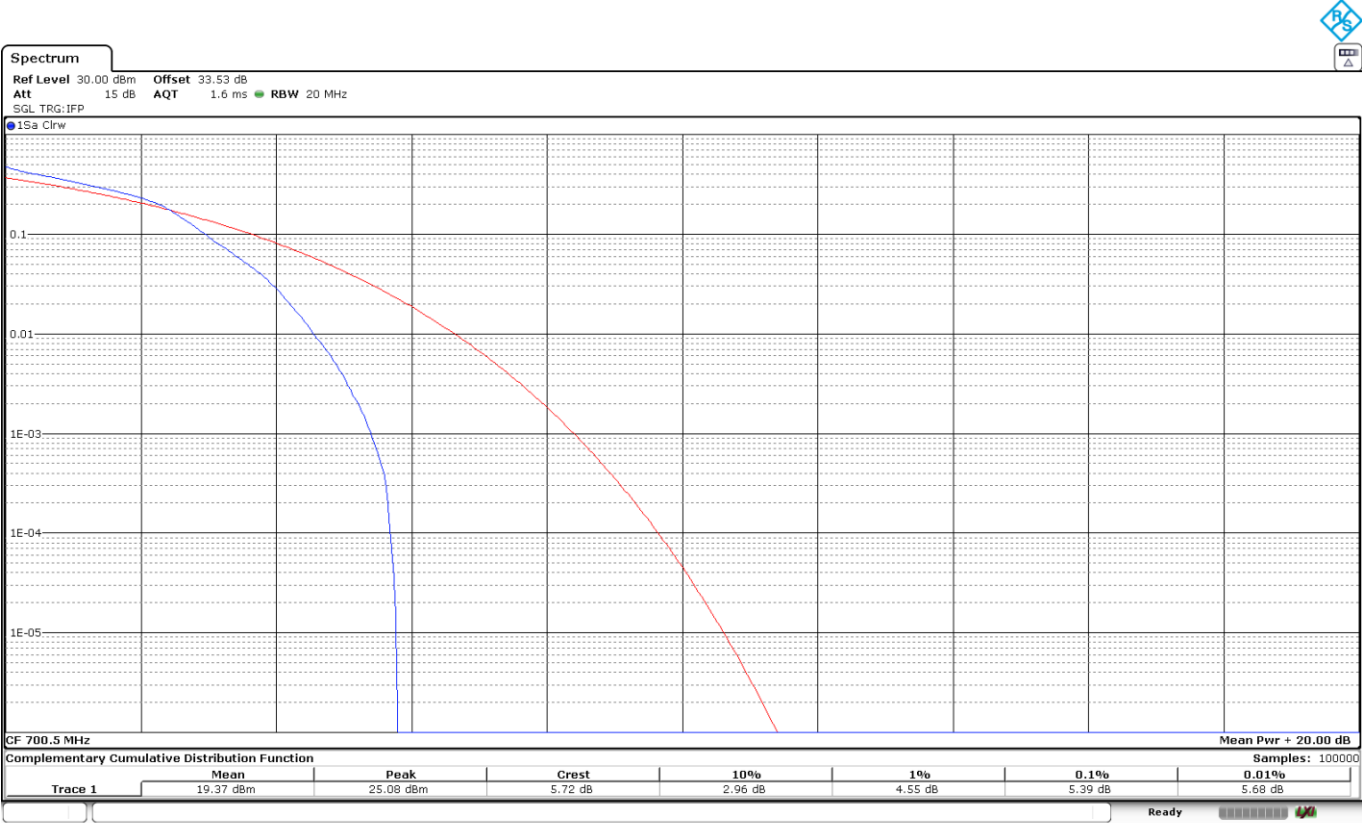
Verdict

Pass

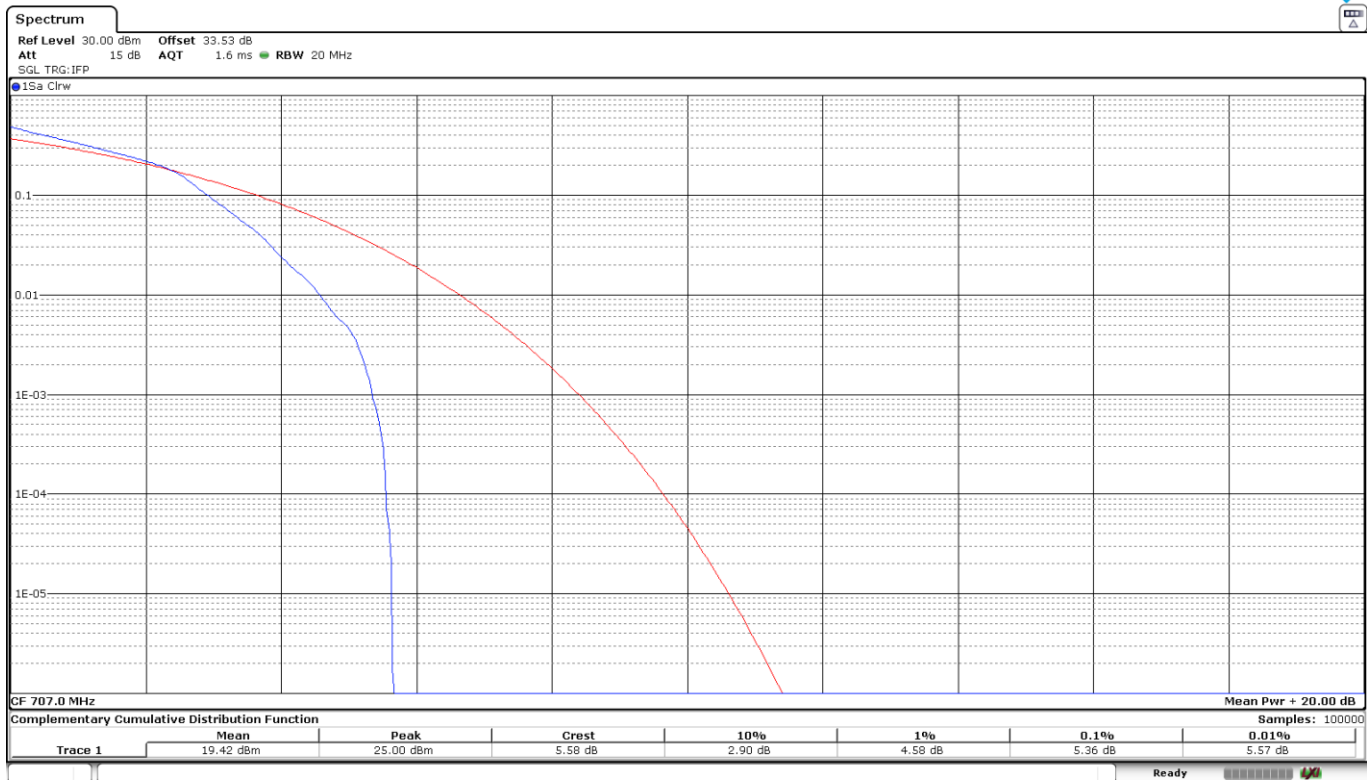
LTE Cat-M1 Band 85:

Worst-case of PAPR is BW=5 MHz. High Channel. 16QAM. RB Size=5. RB Offset=0. Narrowband=1.

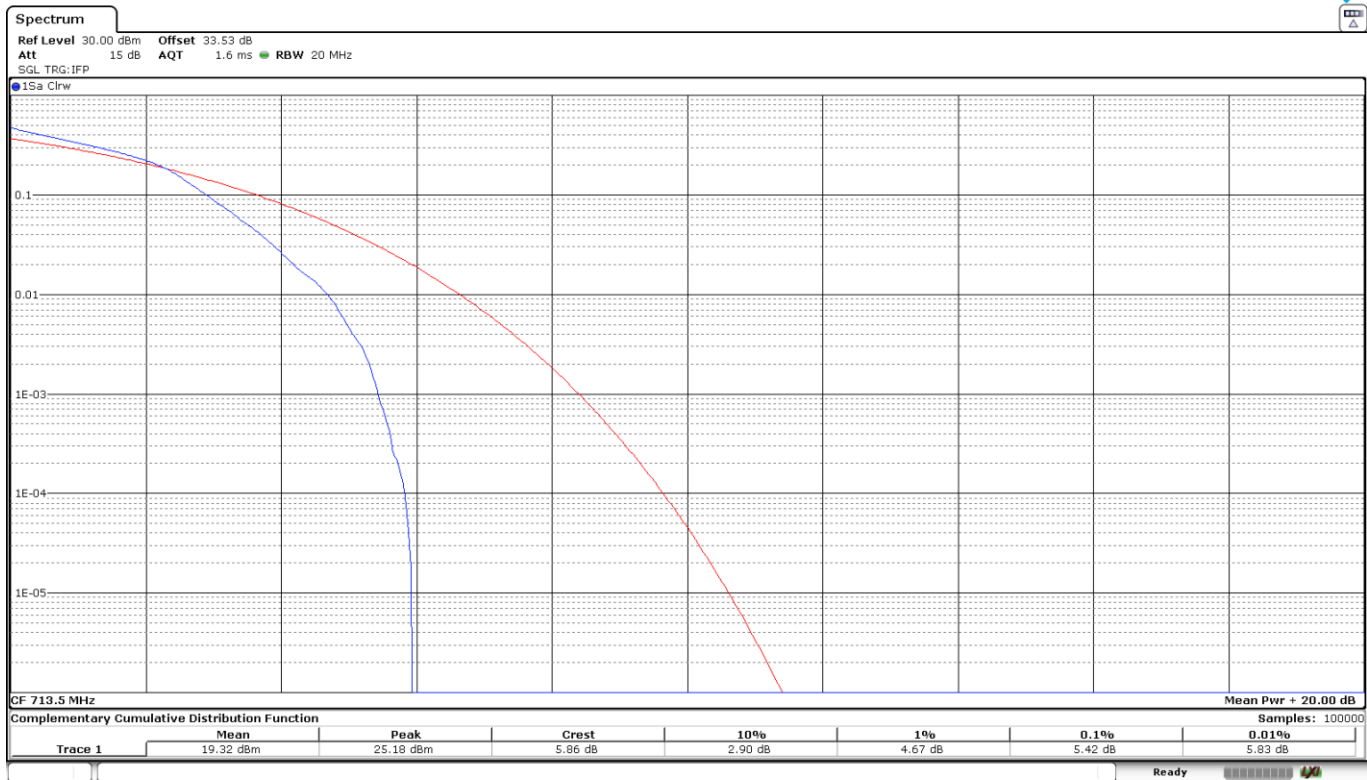
Low Channel:



Middle Channel:



High Channel:



|           |      |        |      |
|-----------|------|--------|------|
| 16QAM     | Low  | Middle | High |
| PAPR (dB) | 5.39 | 5.36   | 5.42 |

**Verdict**

Pass

## Frequency Stability

### **Limits**

\* FCC §27.54 & §2.1055. The frequency stability shall be sufficient to ensure that the fundamental emissions stay within the authorized bands of operation.

\* RSS-130. Clause 4.5 & RSS-139. 5.4. The frequency stability shall be sufficient to ensure that the occupied bandwidth stays within the operating frequency block or frequency block group when tested to the temperature and supply voltage variations specified in RSS-Gen.

### **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.

Temperature and voltage range of testing has been extended to the maximum and minimum values declared by customer.

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.

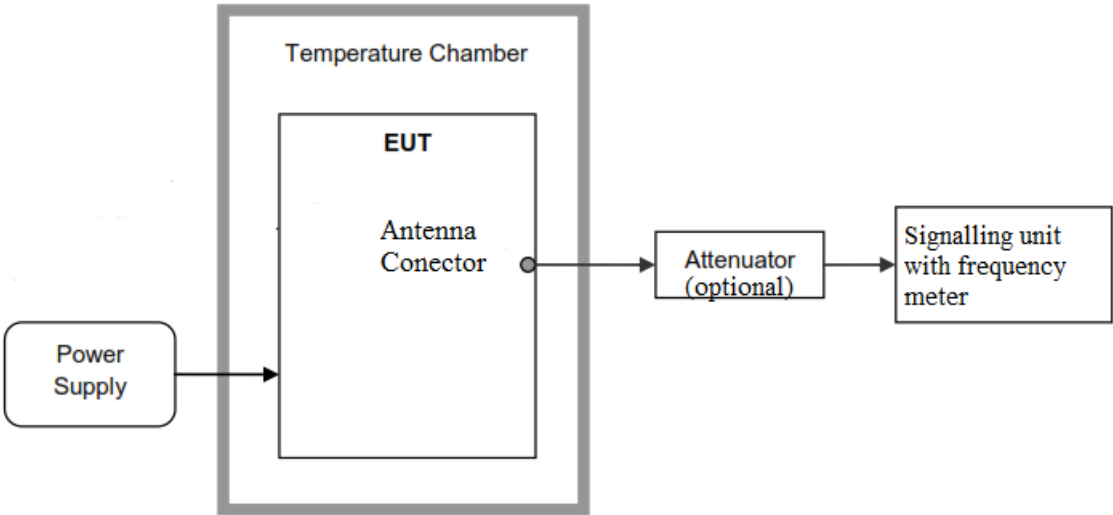
The worst case LTE mode for conducted power was used for the test.

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 channel 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.

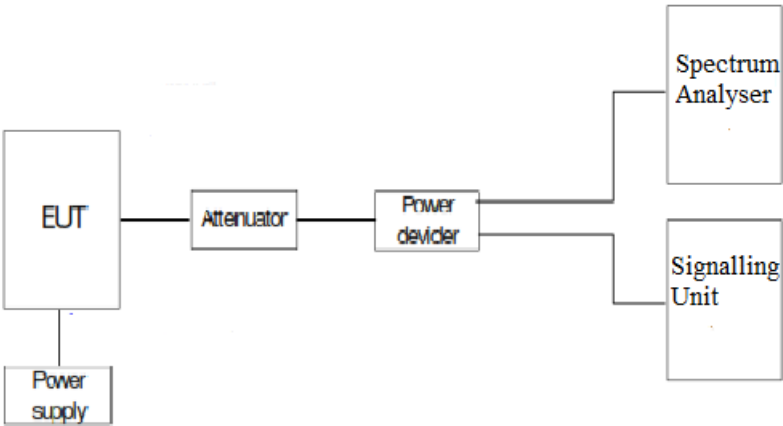
The reference point measurements were made at the RF output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

Test Setup

Frequency tolerance:



Reference points  $f_L$  and  $f_H$ :



Results

1. FREQUENCY TOLERANCE:

- Frequency stability over temperature variations:

LTE Cat-M1 Band 8:

The worst case modulation in terms of Frequency Stability is BW=1.4 MHz. QPSK.

| Temperature (°C) | Frequency Error (Hz) | Frequency Error (ppm) |
|------------------|----------------------|-----------------------|
| +85              | -2.55                | -0.002836485          |
| +80              | -4.1                 | -0.004560623          |
| +70              | 5.42                 | 0.006028921           |
| +60              | -0.58                | -0.000645161          |
| +50              | 0.72                 | 0.00080089            |
| +40              | -0.92                | -0.001023359          |
| +30              | -0.56                | -0.000622914          |
| +20              | -6.63                | -0.007374861          |
| +10              | 4.03                 | 0.004482759           |
| 0                | 3.43                 | 0.00381535            |
| -10              | -5.25                | -0.005839822          |
| -20              | -0.52                | -0.00057842           |
| -30              | -2.03                | -0.002258065          |
| -40              | -0.13                | -0.000144605          |

LTE Cat-M1 Band 13:

The worst case modulation in terms of Frequency Stability is BW=5 MHz. QPSK.

| Temperature (°C) | Frequency Error (Hz) | Frequency Error (ppm) |
|------------------|----------------------|-----------------------|
| 85               | -1.43                | -0.001828645          |
| 80               | -3.23                | -0.004130435          |
| 70               | -4.42                | -0.005652174          |
| 60               | 2                    | 0.002557545           |
| +50              | -6.1                 | -0.007800512          |
| +40              | -1.16                | -0.001483376          |
| +30              | -7.71                | -0.009859335          |
| +20              | -4.59                | -0.005869565          |
| +10              | -6.78                | -0.008670077          |
| 0                | -4.18                | -0.005345269          |
| -10              | -1.44                | -0.001841432          |
| -20              | 5.71                 | 0.00730179            |
| -30              | -8.72                | -0.011150895          |
| -40              | -5.67                | -0.007250639          |

**LTE Cat-M1 Band 66:**

The worst case modulation in terms of Frequency Stability is BW=1.4 MHz. QPSK.

| Temperature (°C) | Frequency Error (Hz) | Frequency Error (ppm) |
|------------------|----------------------|-----------------------|
| +85              | 1.5                  | 0.000859599           |
| +80              | 3.58                 | 0.002051576           |
| +70              | 1.77                 | 0.001014327           |
| +60              | 6.82                 | 0.003908309           |
| +50              | 2.61                 | 0.001495702           |
| +40              | 1.63                 | 0.000934097           |
| +30              | -0.41                | -0.000234957          |
| +20              | 0.24                 | 0.000137536           |
| +10              | 0.83                 | 0.000475645           |
| 0                | -1.56                | -0.000893983          |
| -10              | 3.53                 | 0.002022923           |
| -20              | 0.93                 | 0.000532951           |
| -30              | 0.37                 | 0.000212034           |
| -40              | -0.15                | -8.59599E-05          |

**LTE Cat-M1 Band 85:**

The worst case modulation in terms of Frequency Stability is BW=5 MHz. QPSK.

| Temperature (°C) | Frequency Error (Hz) | Frequency Error (ppm) |
|------------------|----------------------|-----------------------|
| +85              | 2.86                 | 0.004045262           |
| +80              | 5.14                 | 0.007270156           |
| +70              | 3.69                 | 0.005219236           |
| +60              | 2.85                 | 0.004031117           |
| +50              | 5.94                 | 0.008401697           |
| +40              | 5.25                 | 0.007425743           |
| +30              | 3.86                 | 0.005459689           |
| +20              | 4.56                 | 0.006449788           |
| +10              | -6.58                | -0.009306931          |
| 0                | 1.53                 | 0.002164074           |
| -10              | 0.94                 | 0.001329562           |
| -20              | 1.59                 | 0.002248939           |
| -30              | -2.56                | -0.003620934          |
| -40              | 3.34                 | 0.004724187           |

- **Frequency stability over voltage variations:**

#### **LTE Cat-M1 Band 8:**

The worst case modulation in terms of Frequency Stability is BW=1.4 MHz. QPSK.

| Supply voltage | Voltage (V) | Frequency Error (Hz) | Frequency Error (ppm) |
|----------------|-------------|----------------------|-----------------------|
| Vmax           | 5.5         | -5.93                | -0.006596218          |
| Vmin           | 3           | 3.43                 | 0.00381535            |

#### **LTE Cat-M1 Band 13:**

The worst case modulation in terms of Frequency Stability is BW=5 MHz. QPSK.

| Supply voltage | Voltage (V) | Frequency Error (Hz) | Frequency Error (ppm) |
|----------------|-------------|----------------------|-----------------------|
| Vmax           | 5.5         | -3.19                | -0.004079284          |
| Vmin           | 3           | -4.52                | -0.005780051          |

#### **LTE Cat-M1 Band 66:**

The worst case modulation in terms of Frequency Stability is BW=1.4 MHz. QPSK.

| Supply voltage | Voltage (V) | Frequency Error (Hz) | Frequency Error (ppm) |
|----------------|-------------|----------------------|-----------------------|
| Vmax           | 5.5         | -2.7                 | -0.001547278          |
| Vmin           | 3           | -1.07                | -0.000613181          |

#### **LTE Cat-M1 Band 85:**

The worst case modulation in terms of Frequency Stability is BW=5 MHz. QPSK.

| Supply voltage | Voltage (V) | Frequency Error (Hz) | Frequency Error (ppm) |
|----------------|-------------|----------------------|-----------------------|
| Vmax           | 5.5         | -0.53                | -0.000749646          |
| Vmin           | 3           | 0.2                  | 0.000282885           |

2. REFERENCE FREQUENCY POINTS fL AND fH:

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

**LTE Cat-M1 Band 4:** BW=1.4 MHz. QPSK.

|          |           |
|----------|-----------|
| fL (MHz) | 1710.0205 |
| fH (MHz) | 1754.9640 |

**LTE Cat-M1 Band 8:** BW=1.4 MHz. QPSK.

|          |          |
|----------|----------|
| fL (MHz) | 897.5436 |
| fH (MHz) | 900.4520 |

**LTE Cat-M1 Band 12:** BW=1.4 MHz. QPSK.

|          |          |
|----------|----------|
| fL (MHz) | 699.0171 |
| fH (MHz) | 715.9734 |

**LTE Cat-M1 Band 13:** BW=5 MHz. QPSK.

|          |          |
|----------|----------|
| fL (MHz) | 777.1115 |
| fH (MHz) | 786.8845 |

**LTE Cat-M1 Band 66:** BW=1.4 MHz. QPSK.

|          |           |
|----------|-----------|
| fL (MHz) | 1710.0205 |
| fH (MHz) | 1779.9669 |

**LTE Cat-M1 Band 85:** BW=5 MHz. QPSK.

|          |          |
|----------|----------|
| fL (MHz) | 698.1129 |
| fH (MHz) | 715.9734 |

The reference frequency points fL and fH stay within the authorized blocks for the band above.

Measurement uncertainty (Hz): <±207.77

**Verdict**

PASS

## Modulation Characteristics

### Limits

FCC §2.1047.

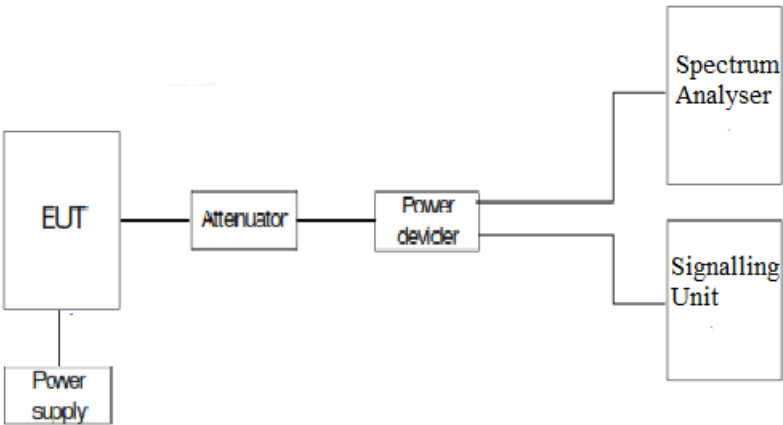
RSS-130. 4.2: Equipment certified under this standard shall employ digital modulation.

RSS-139. 5.3: Devices may use any type of modulation technique. The type of modulation shall be documented in the test report.

### Method

For LTE the EUT operates with QPSK and 16QAM modulation modes in which the information is digitised 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

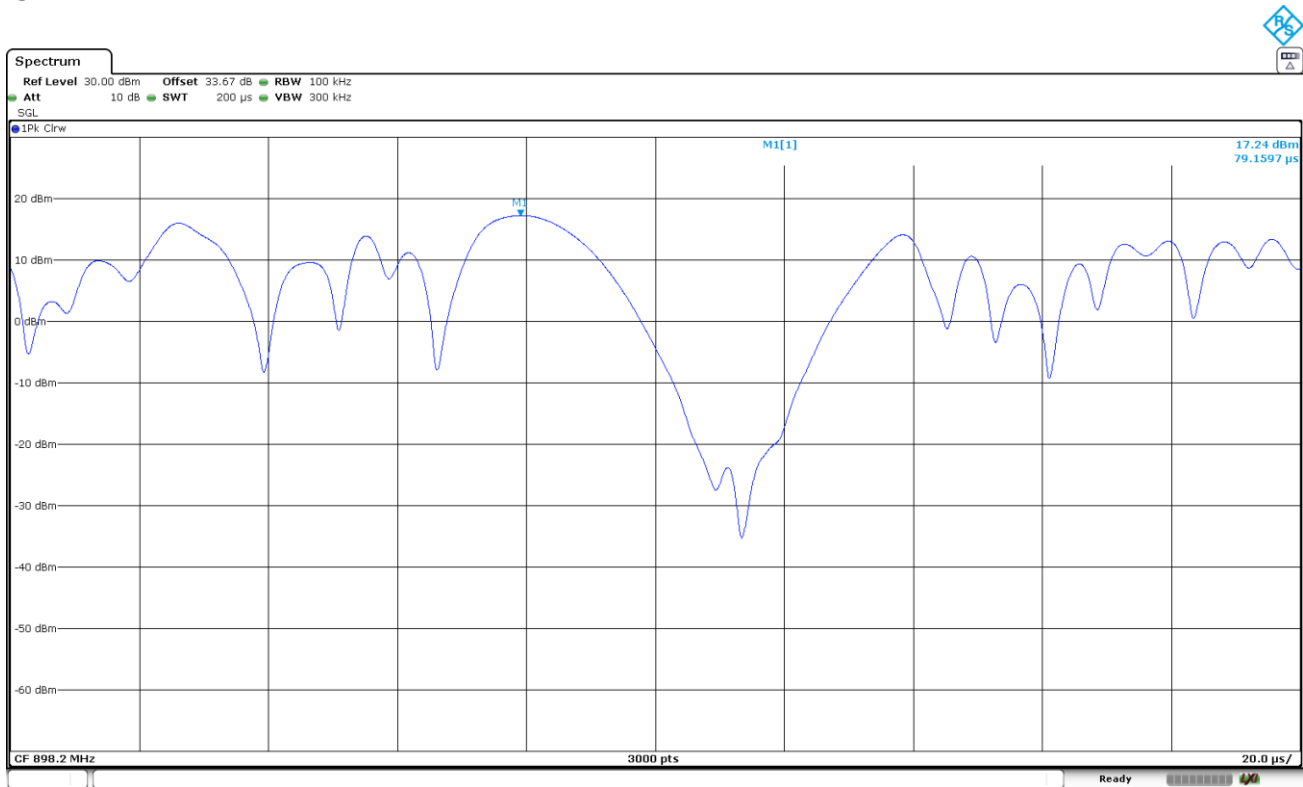


Results

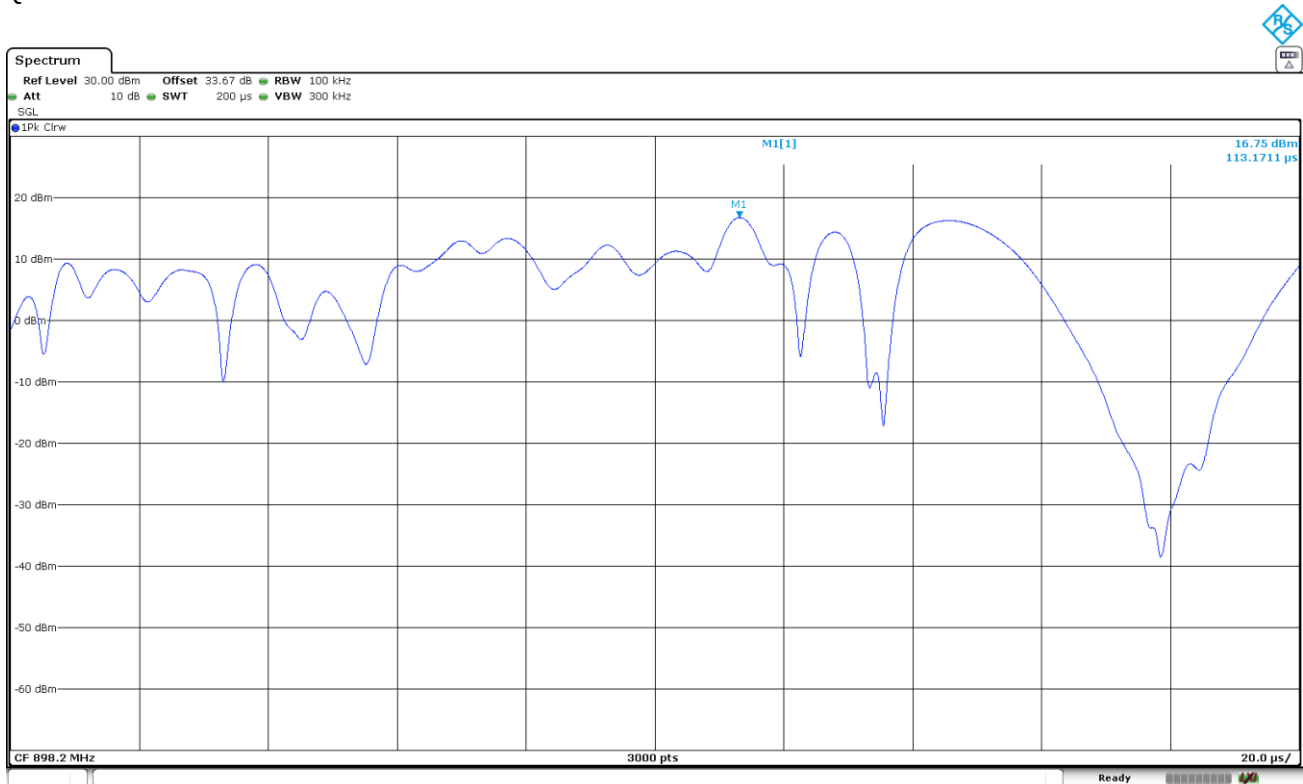
The following plots show the modulation schemes in the EUT.

LTE Cat-M1 Band 8:

QPSK. BW=1.4 MHz.

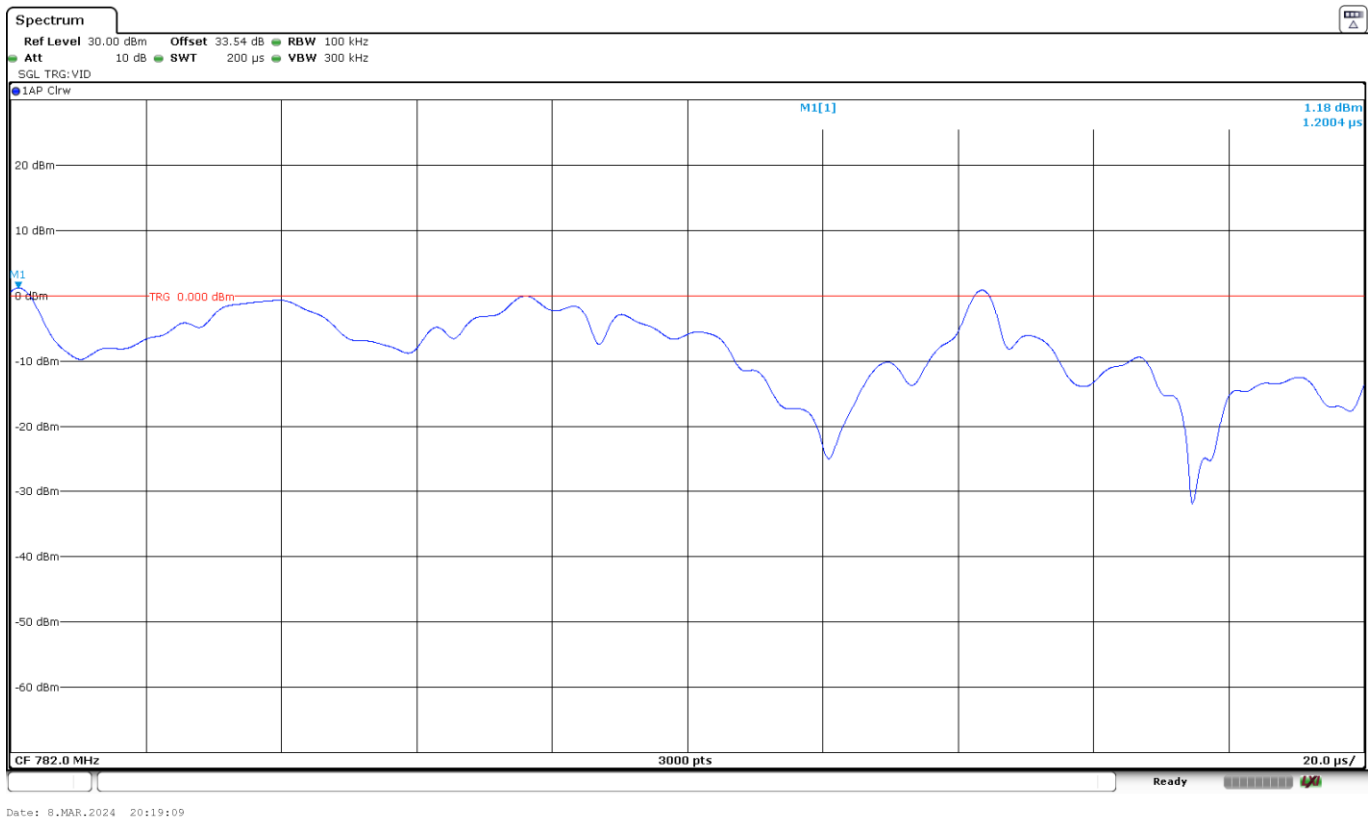


16QAM. BW=1.4 MHz.

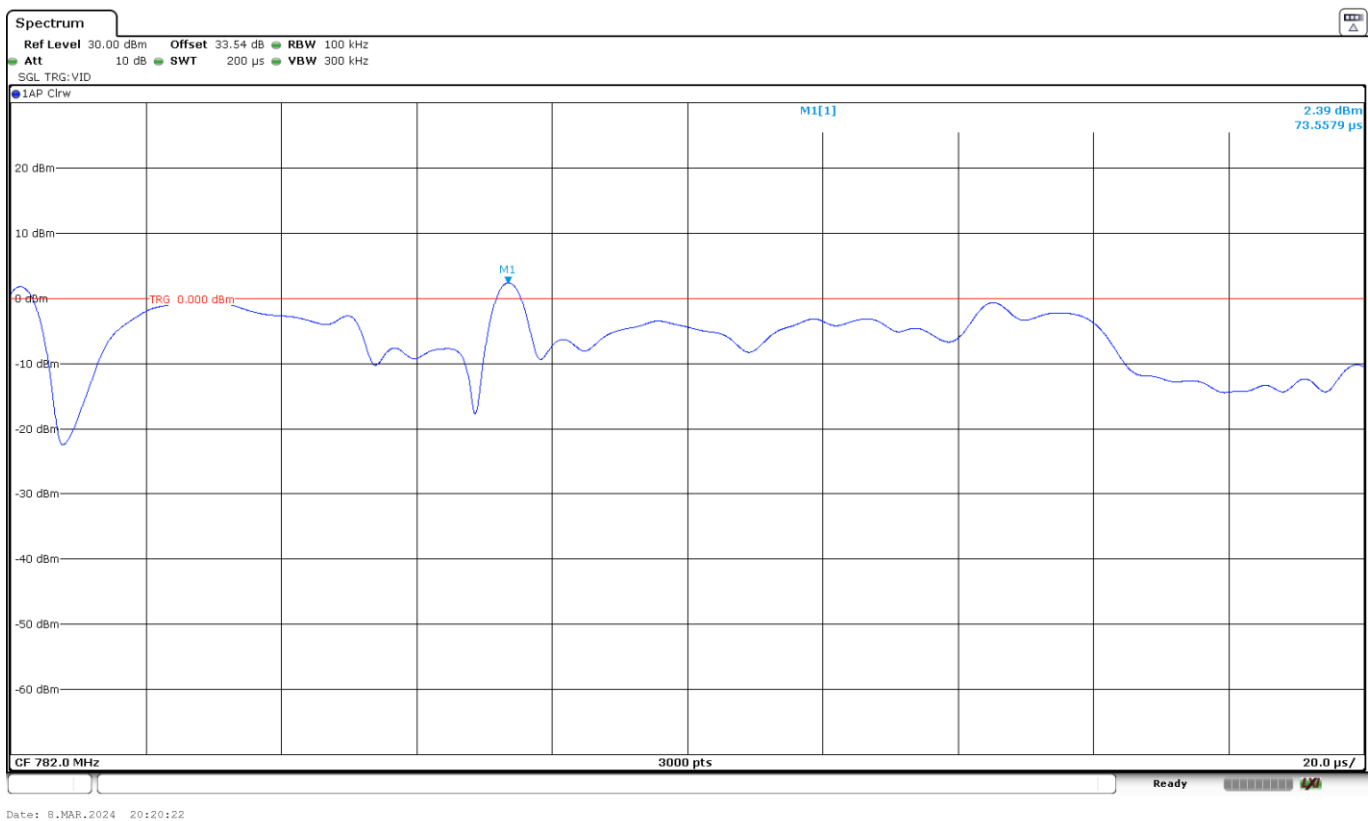


LTE Cat-M1 Band 13:

QPSK. BW=5 MHz.

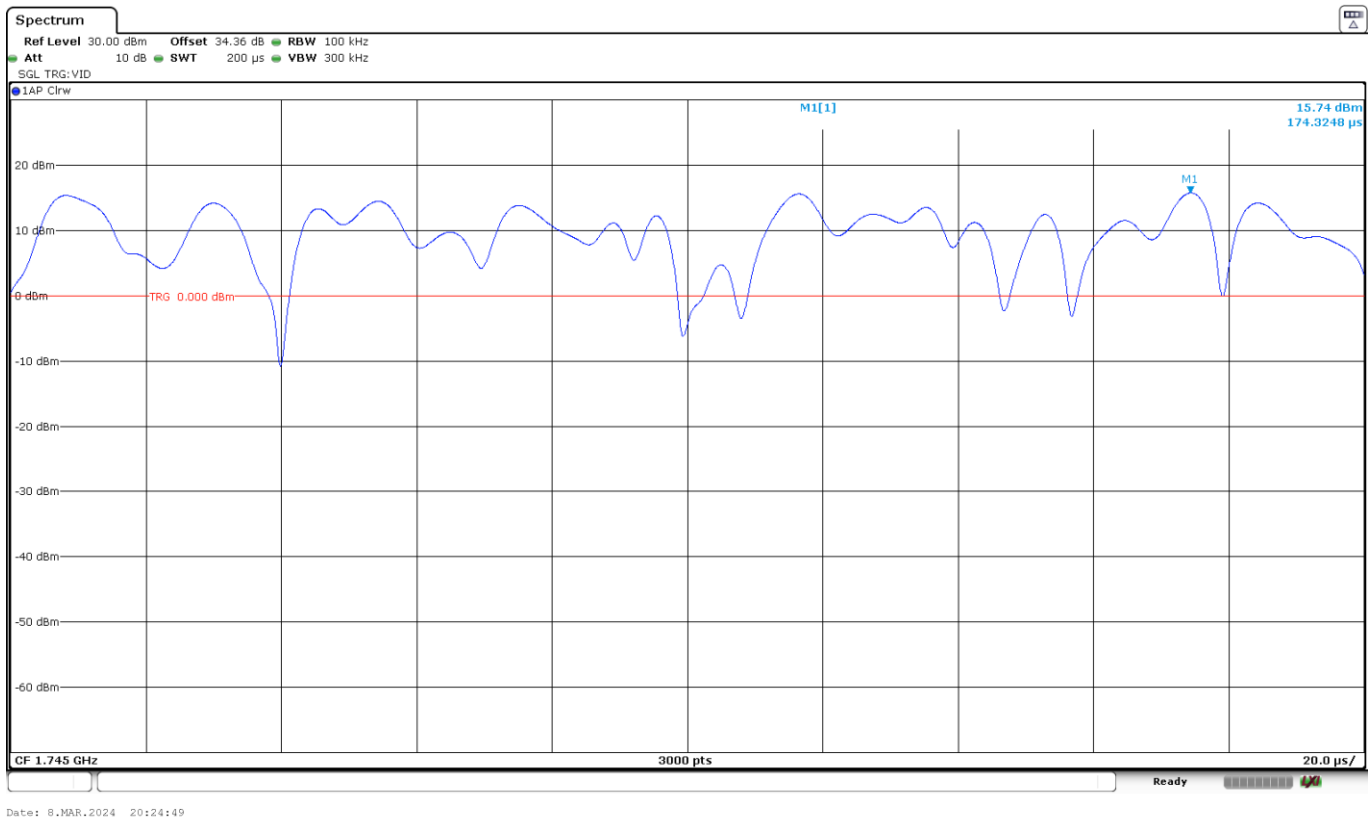


16QAM. BW=5 MHz.

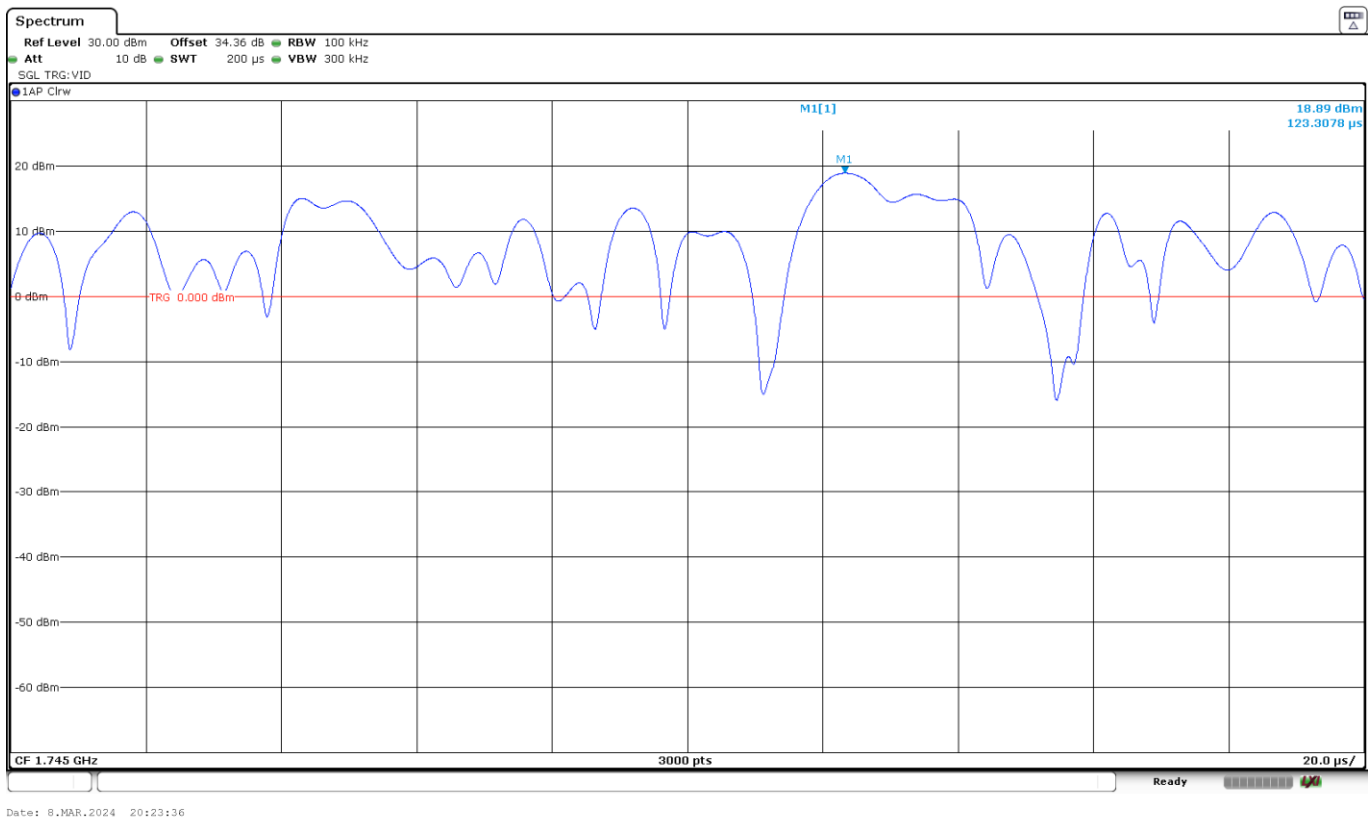


LTE Cat-M1 Band 66:

QPSK. BW=1.4 MHz.

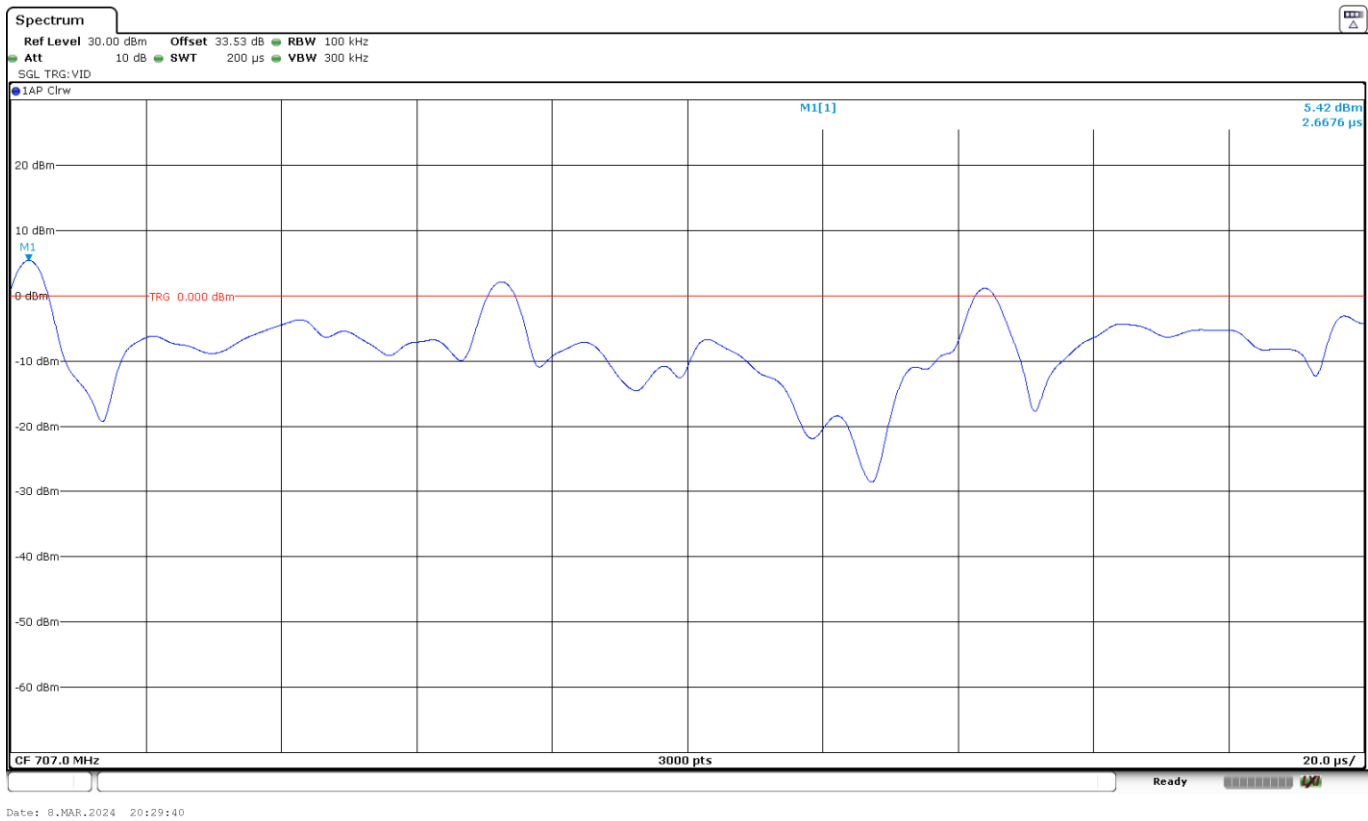


16QAM. BW=1.4 MHz.

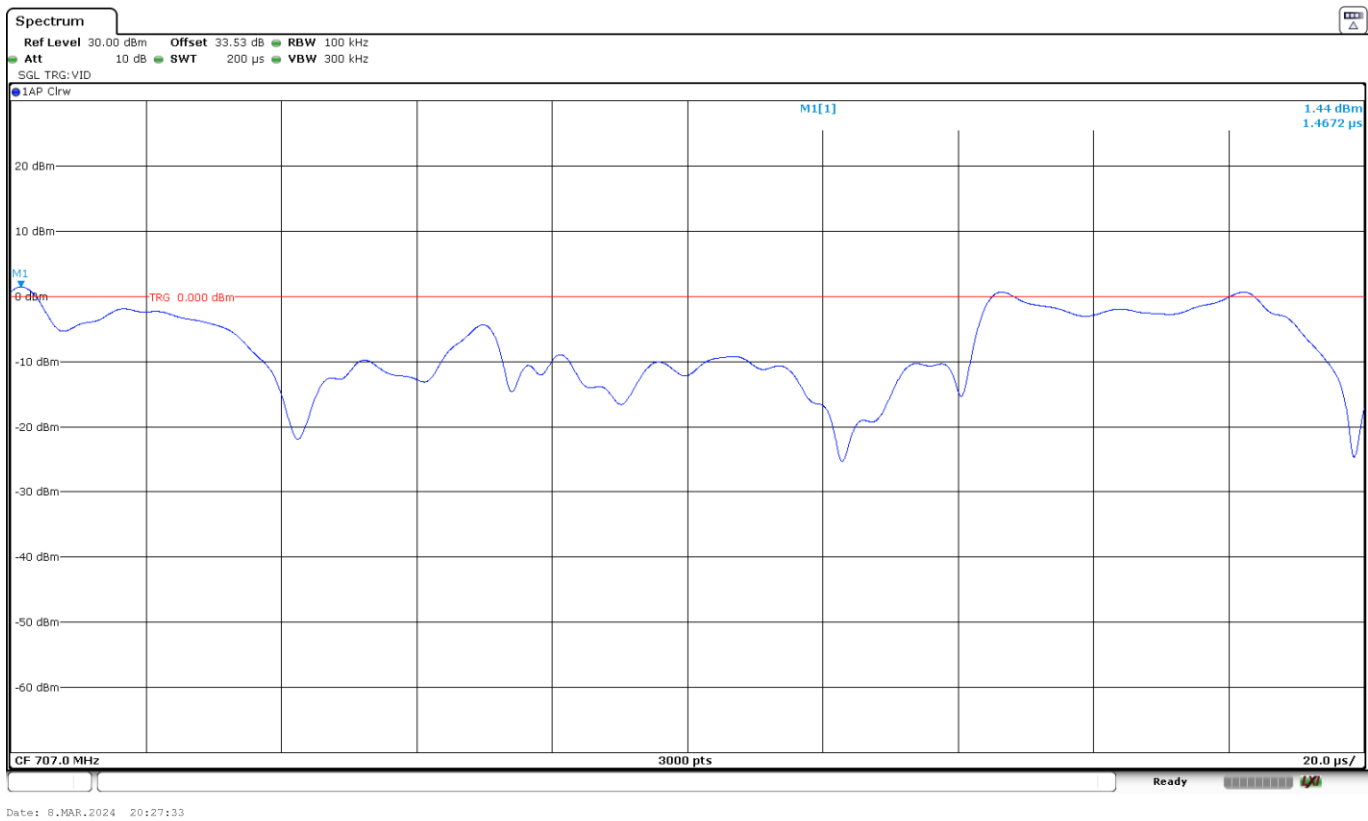


LTE Cat-M1 Band 85:

QPSK. BW=5 MHz.



16QAM. BW=5 MHz.



## Occupied Bandwidth

### Limits

FCC §2.1049: Measurements required: Occupied bandwidth.

RSS-Gen 6.7. 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.

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.

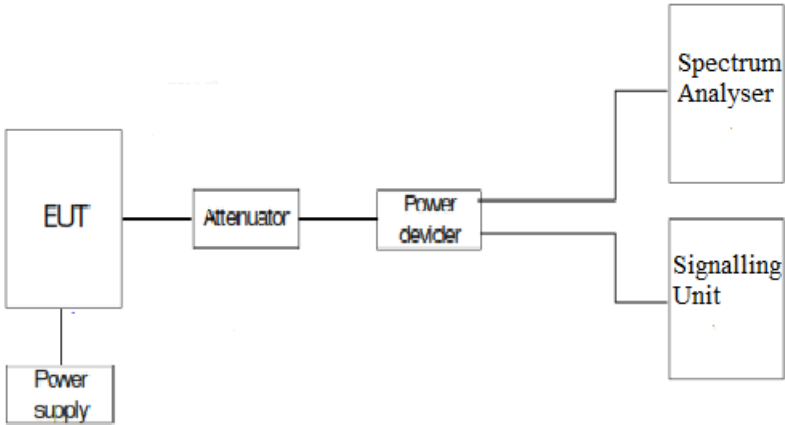
Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.

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).

### 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 all Resource Blocks (RB) offset 0 regardless either the Narrowband or the Bandwidth selected.

LTE Cat-M1 Band 8:

LTE Cat-M1 Band 8. BW=1.4 MHz. QPSK. RB Size 6.

| Channel                       | Low    | High  |
|-------------------------------|--------|-------|
| 99% Occupied Bandwidth (MHz)  | 1.017  | 1.105 |
| -26 dBc Bandwidth (MHz)       | 1.326  | 1.327 |
| Measurement uncertainty (kHz) | <±3.75 |       |

LTE Cat-M1 Band 8. BW=1.4 MHz. 16QAM. RB Size 5.

| Channel                       | Low    | High  |
|-------------------------------|--------|-------|
| 99% Occupied Bandwidth (MHz)  | 0.960  | 0.970 |
| -26 dBc Bandwidth (MHz)       | 1.315  | 1.313 |
| Measurement uncertainty (kHz) | <±3.75 |       |

LTE Cat-M1 Band 13:

LTE Cat-M1 Band 13. BW=5 MHz. QPSK. RB Size 6.

| Channel                       | Low     | High    |
|-------------------------------|---------|---------|
| 99% Occupied Bandwidth (MHz)  | 1.09433 | 1.10367 |
| -26 dBc Bandwidth (MHz)       | 1.34294 | 1.34168 |
| Measurement uncertainty (kHz) | <±3.75  |         |

LTE Cat-M1 Band 13. BW=5 MHz. 16QAM. RB Size 5.

| Channel                       | Low     | High    |
|-------------------------------|---------|---------|
| 99% Occupied Bandwidth (MHz)  | 0.94033 | 0.94267 |
| -26 dBc Bandwidth (MHz)       | 1.28930 | 1.28568 |
| Measurement uncertainty (kHz) | <±3.75  |         |

**LTE Cat-M1 Band 66:**

LTE Cat-M1 Band 66. BW=1.4 MHz. QPSK. RB Size 6.

| Channel                       | Low    | Middle | High  |
|-------------------------------|--------|--------|-------|
| 99% Occupied Bandwidth (MHz)  | 1.098  | 1.097  | 1.097 |
| -26 dBc Bandwidth (MHz)       | 1.321  | 1.325  | 1.327 |
| Measurement uncertainty (kHz) | <±3.75 |        |       |

LTE Cat-M1 Band 66. BW=1.4 MHz. 16QAM. RB Size 5.

| Channel                       | Low    | Middle | High  |
|-------------------------------|--------|--------|-------|
| 99% Occupied Bandwidth (MHz)  | 0.947  | 0.944  | 0.939 |
| -26 dBc Bandwidth (MHz)       | 1.333  | 1.287  | 1.291 |
| Measurement uncertainty (kHz) | <±3.75 |        |       |

**LTE Cat-M1 Band 85:**

LTE Cat-M1 Band 85. BW=5 MHz. QPSK. RB Size 6.

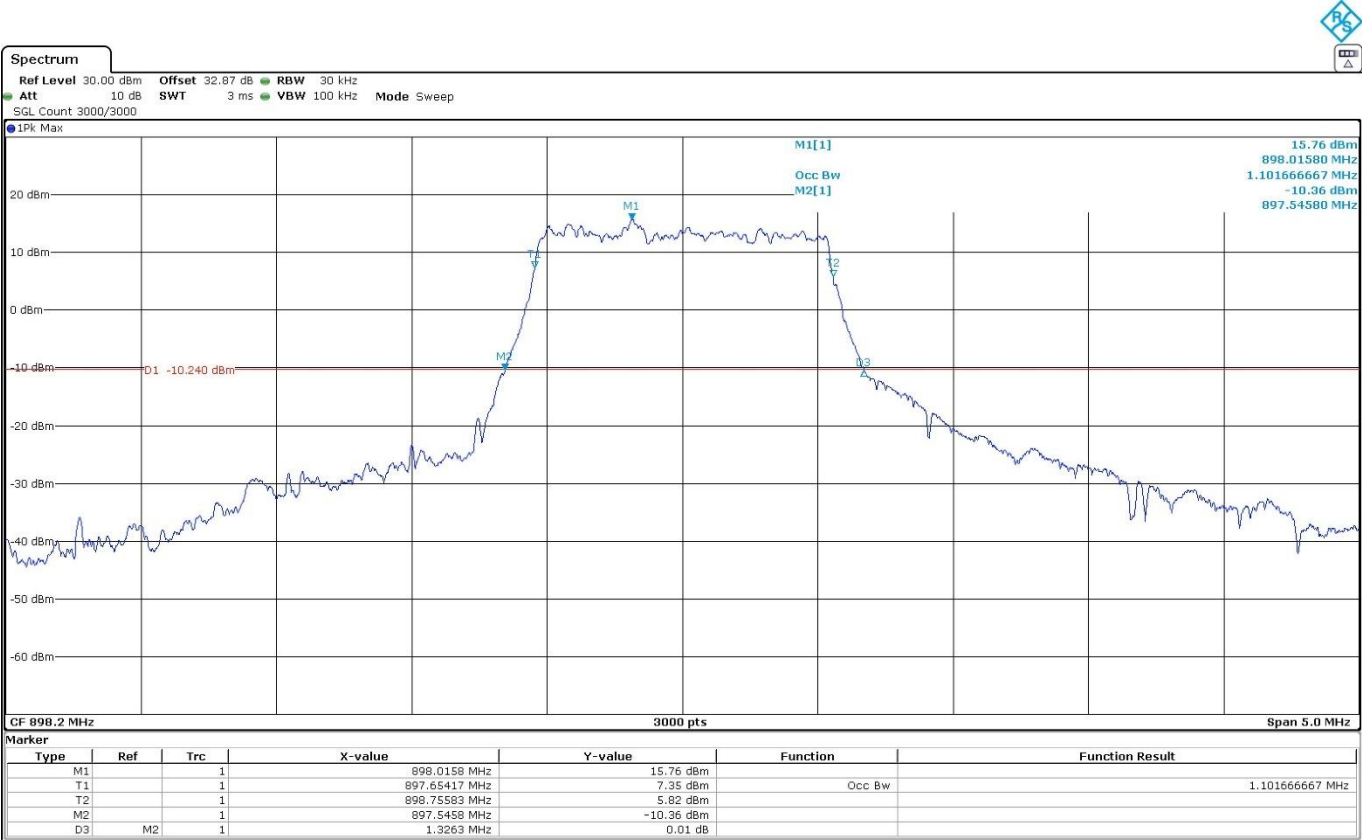
| Channel                       | Low    | Middle | High  |
|-------------------------------|--------|--------|-------|
| 99% Occupied Bandwidth (MHz)  | 1.104  | 1.106  | 1.094 |
| -26 dBc Bandwidth (MHz)       | 1.335  | 1.336  | 1.321 |
| Measurement uncertainty (kHz) | <±3.75 |        |       |

LTE Cat-M1 Band 85. BW=5 MHz. 16QAM. RB Size 5.

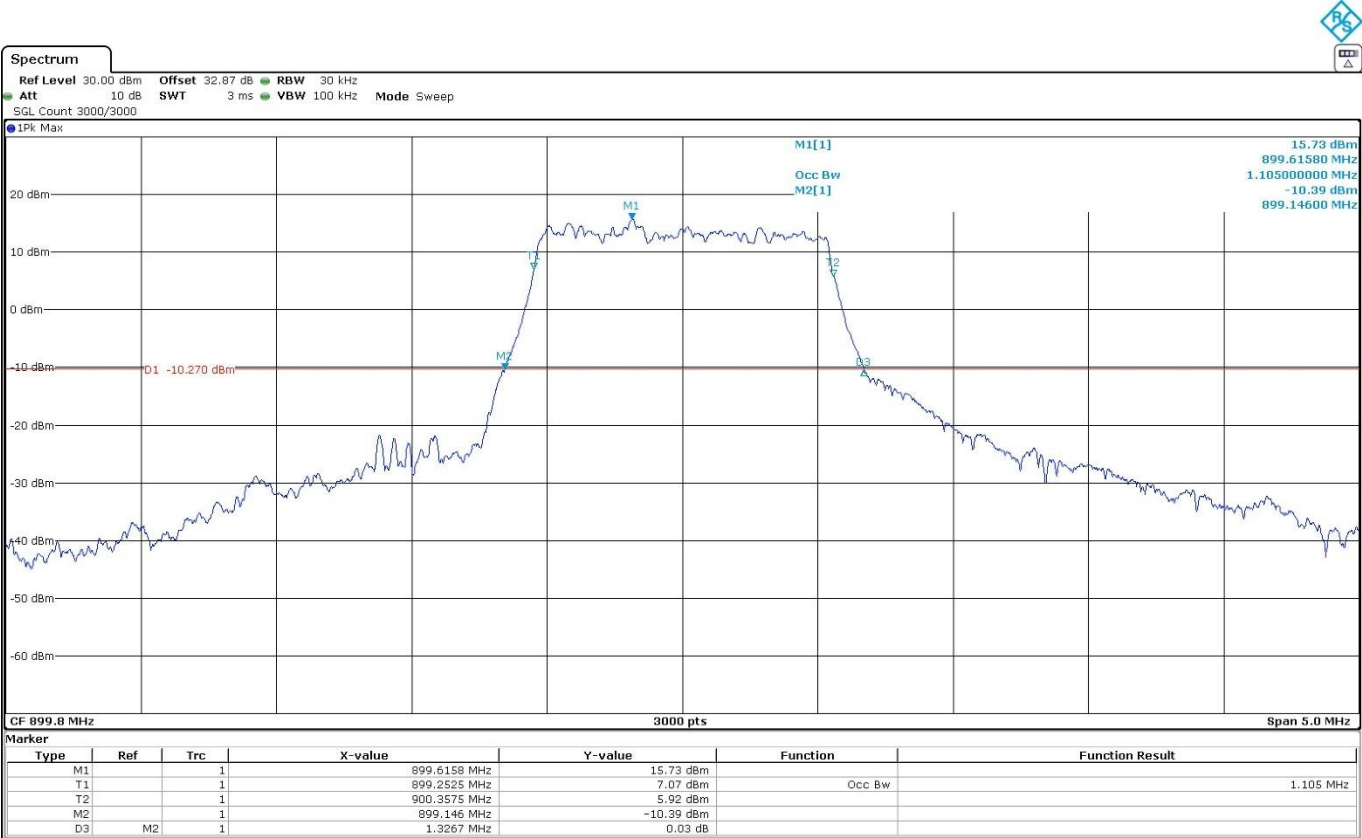
| Channel                       | Low    | Middle | High  |
|-------------------------------|--------|--------|-------|
| 99% Occupied Bandwidth (MHz)  | 0.973  | 0.952  | 0.945 |
| -26 dBc Bandwidth (MHz)       | 1.316  | 1.310  | 1.295 |
| Measurement uncertainty (kHz) | <±3.75 |        |       |

LTE Cat-M1 Band 8. BW=1.4 MHz. QPSK. RB Size 6.

Low Channel:

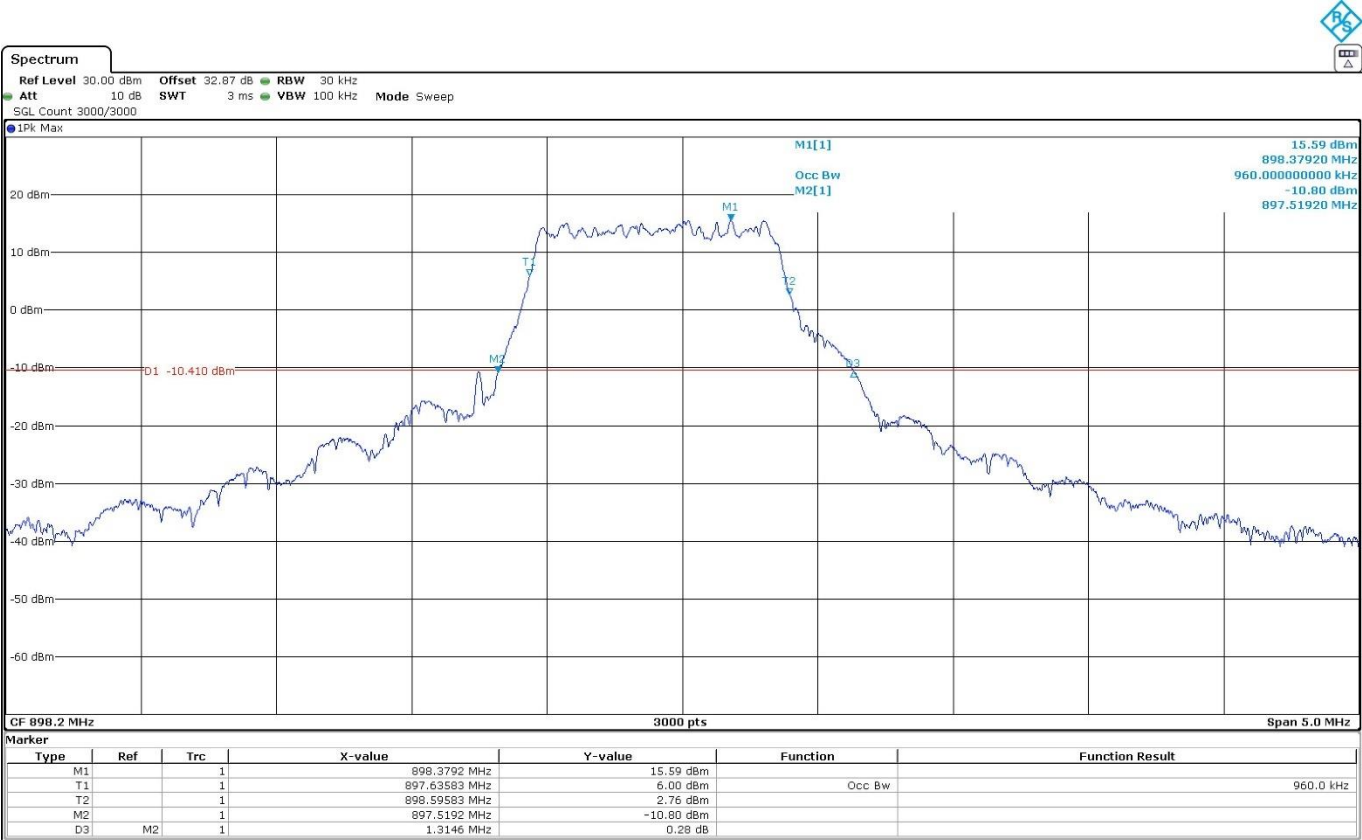


High Channel:

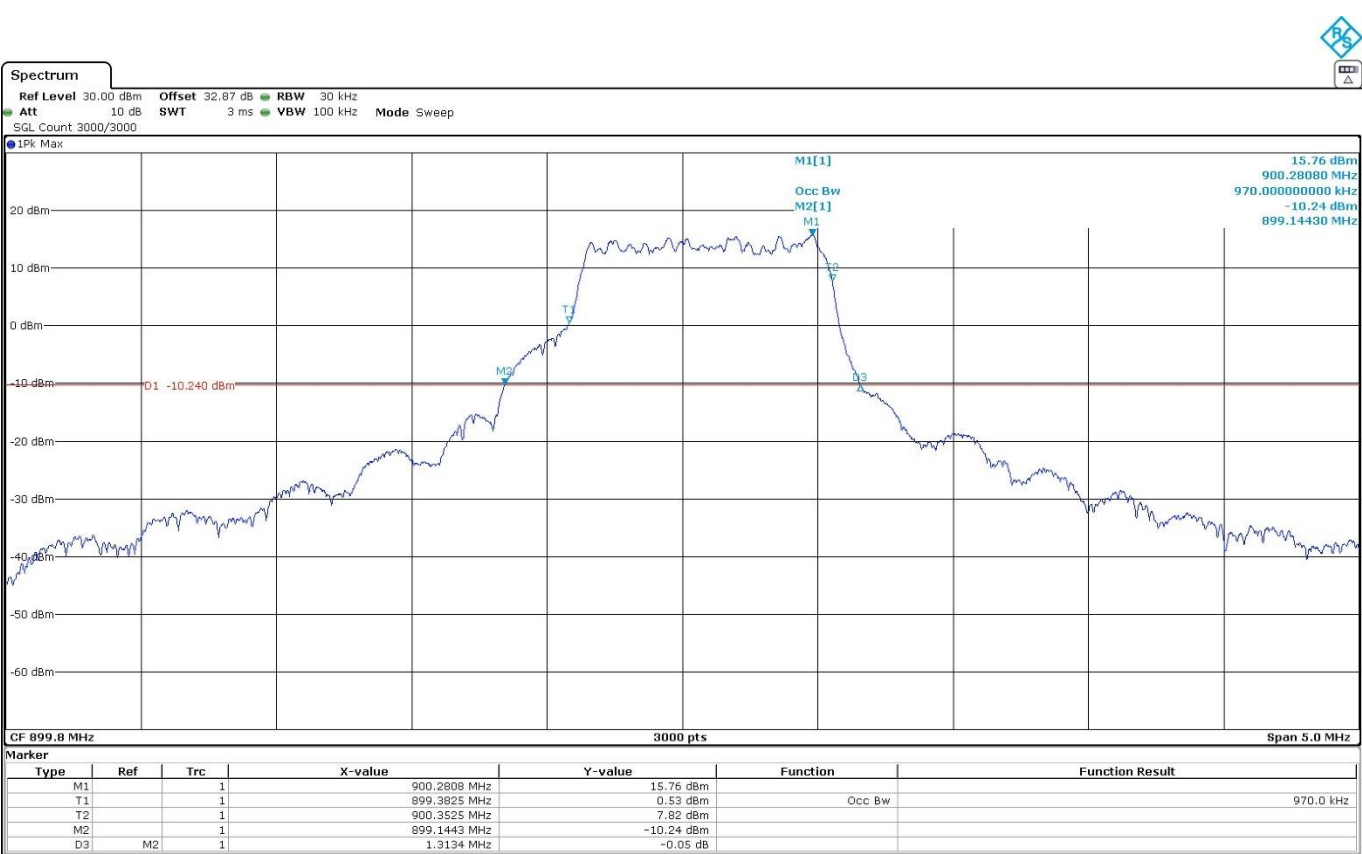


LTE Cat-M1 Band 8. BW=1.4 MHz. 16QAM. RB Size 5.

Low Channel:

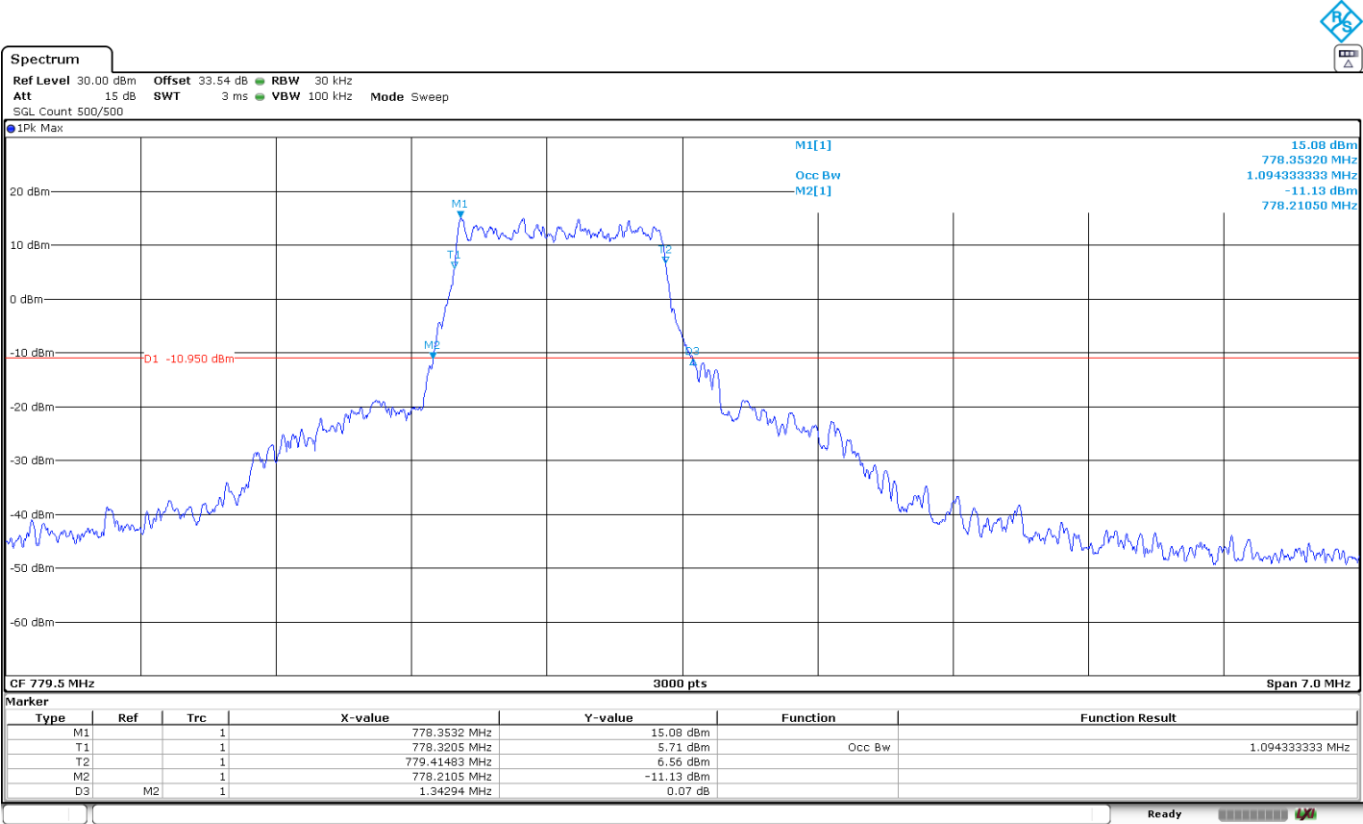


High Channel:

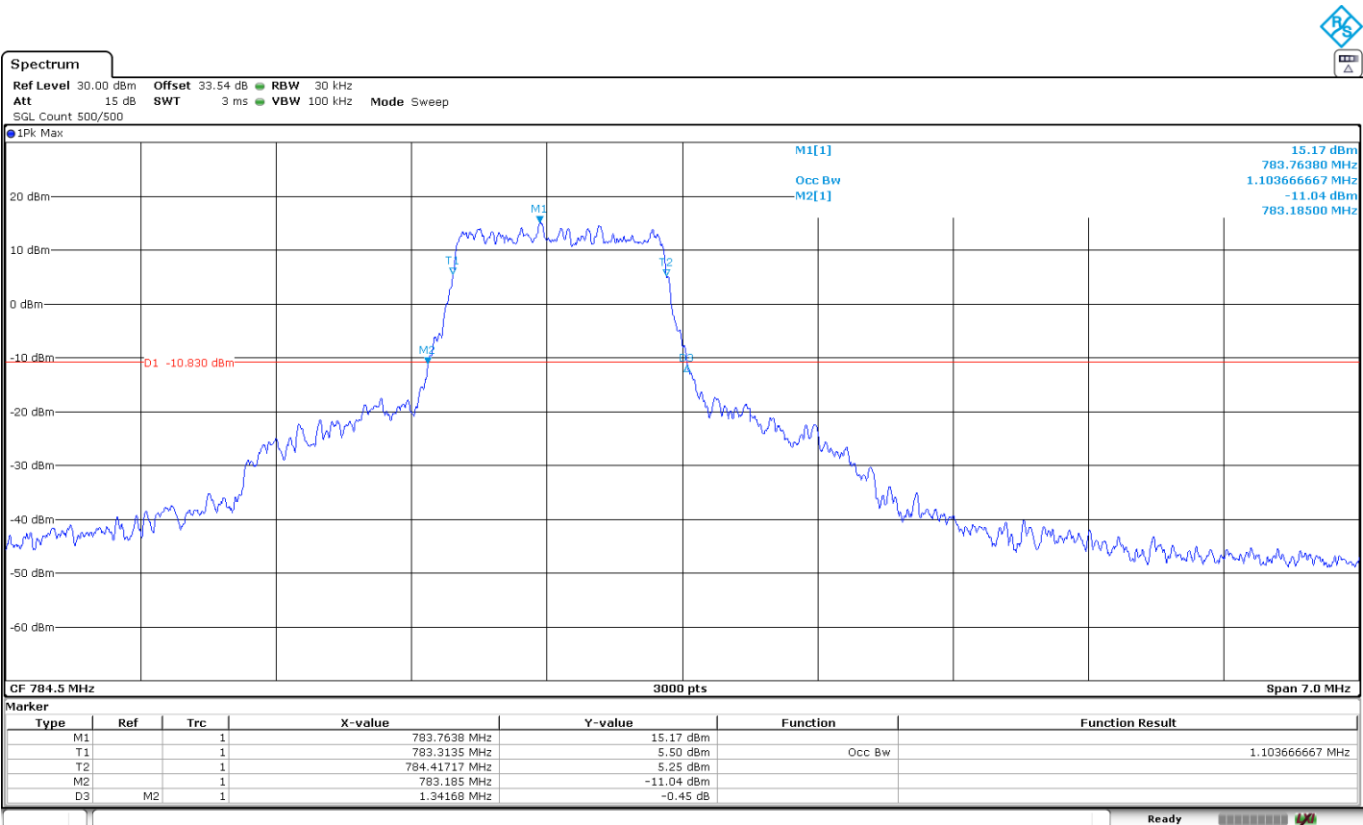


LTE Cat-M1 Band 13. BW=5 MHz. QPSK. RB Size 6.

Low Channel:

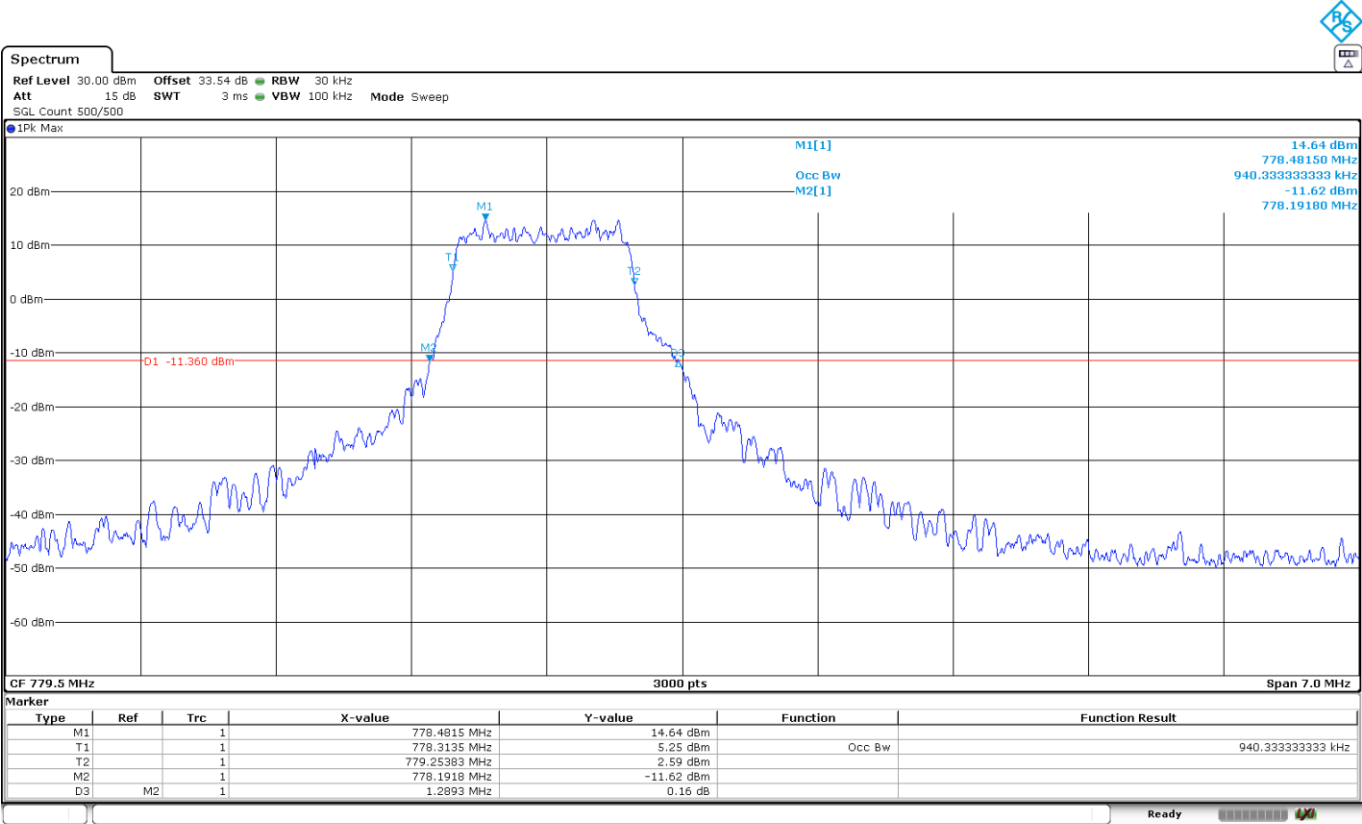


High Channel:

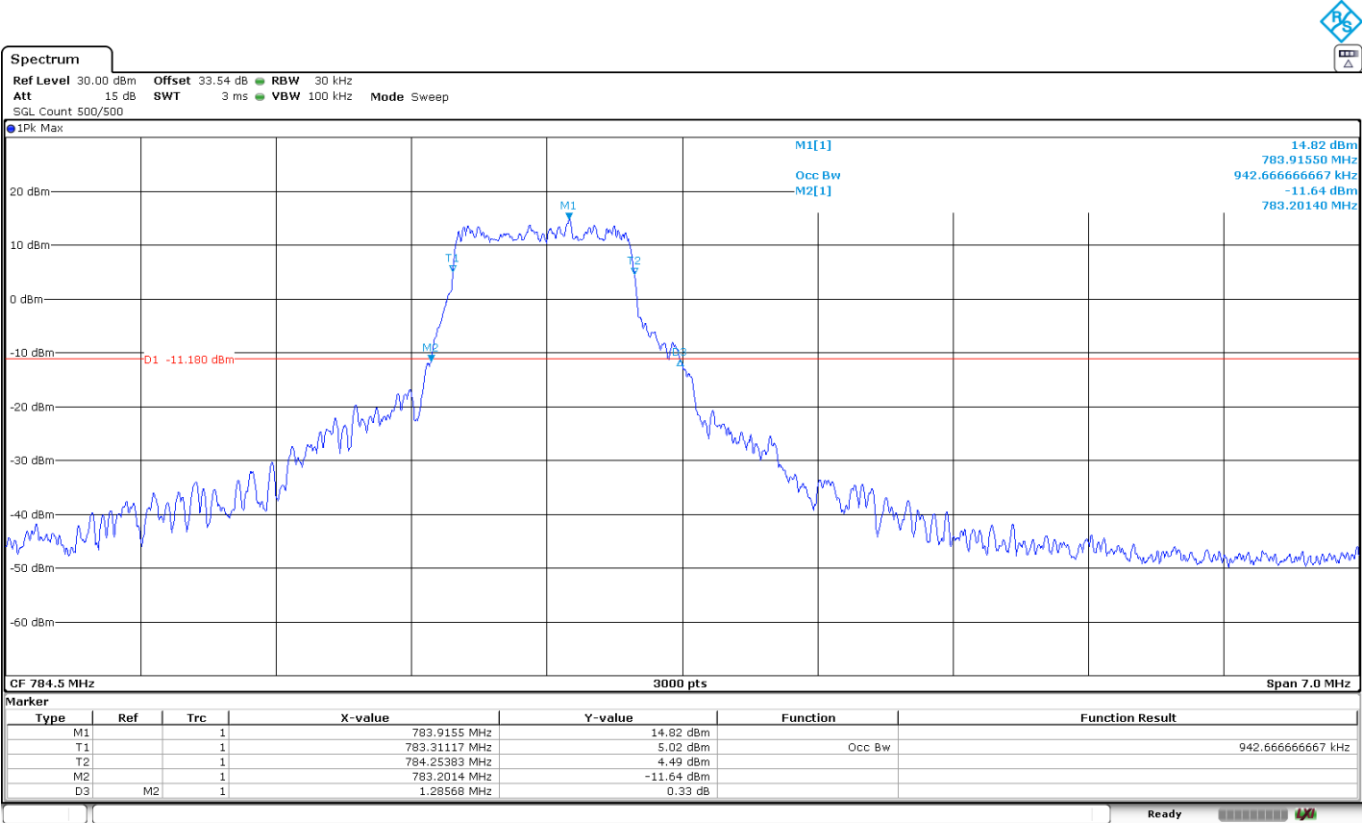


LTE Cat-M1 Band 13. BW=5 MHz. 16QAM. RB Size 5.

Low Channel:

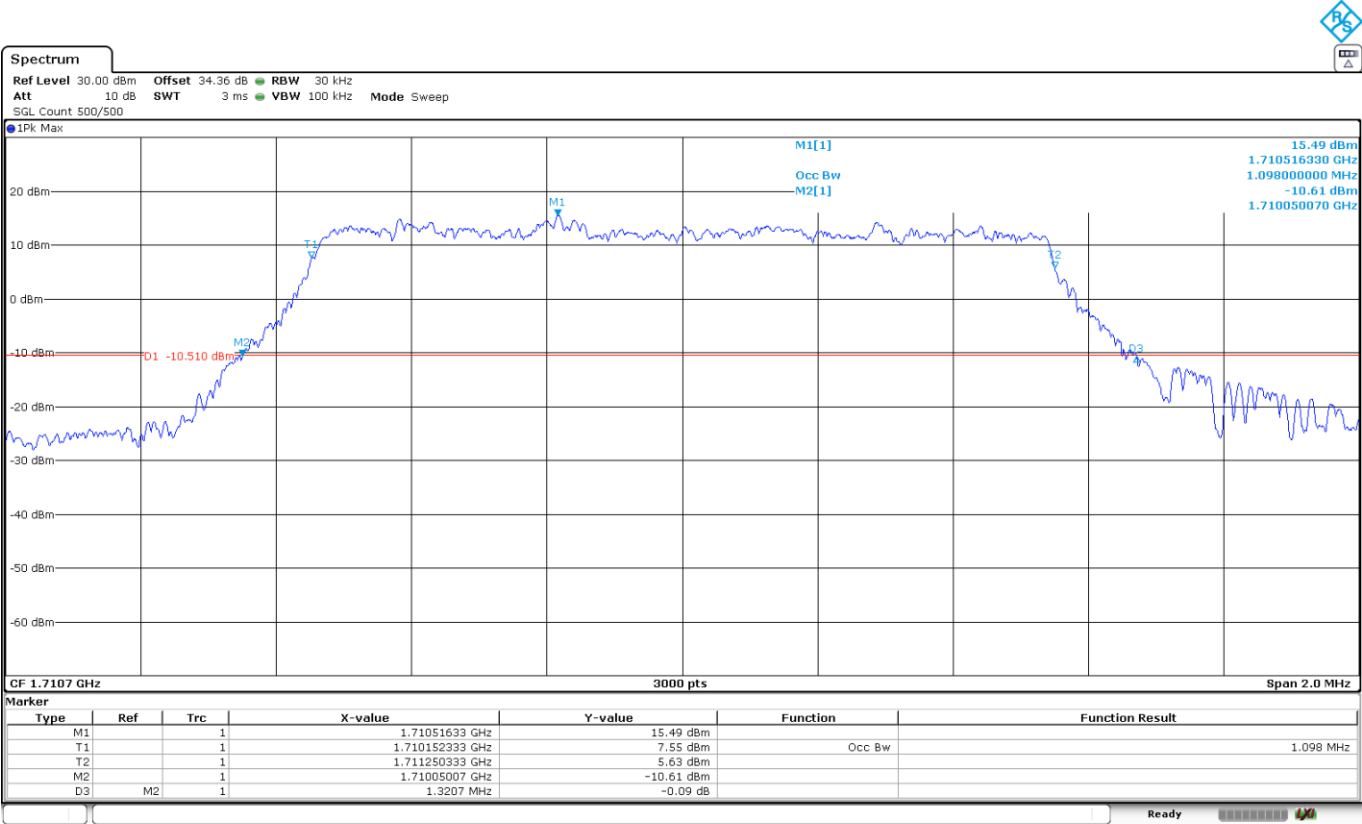


High Channel:

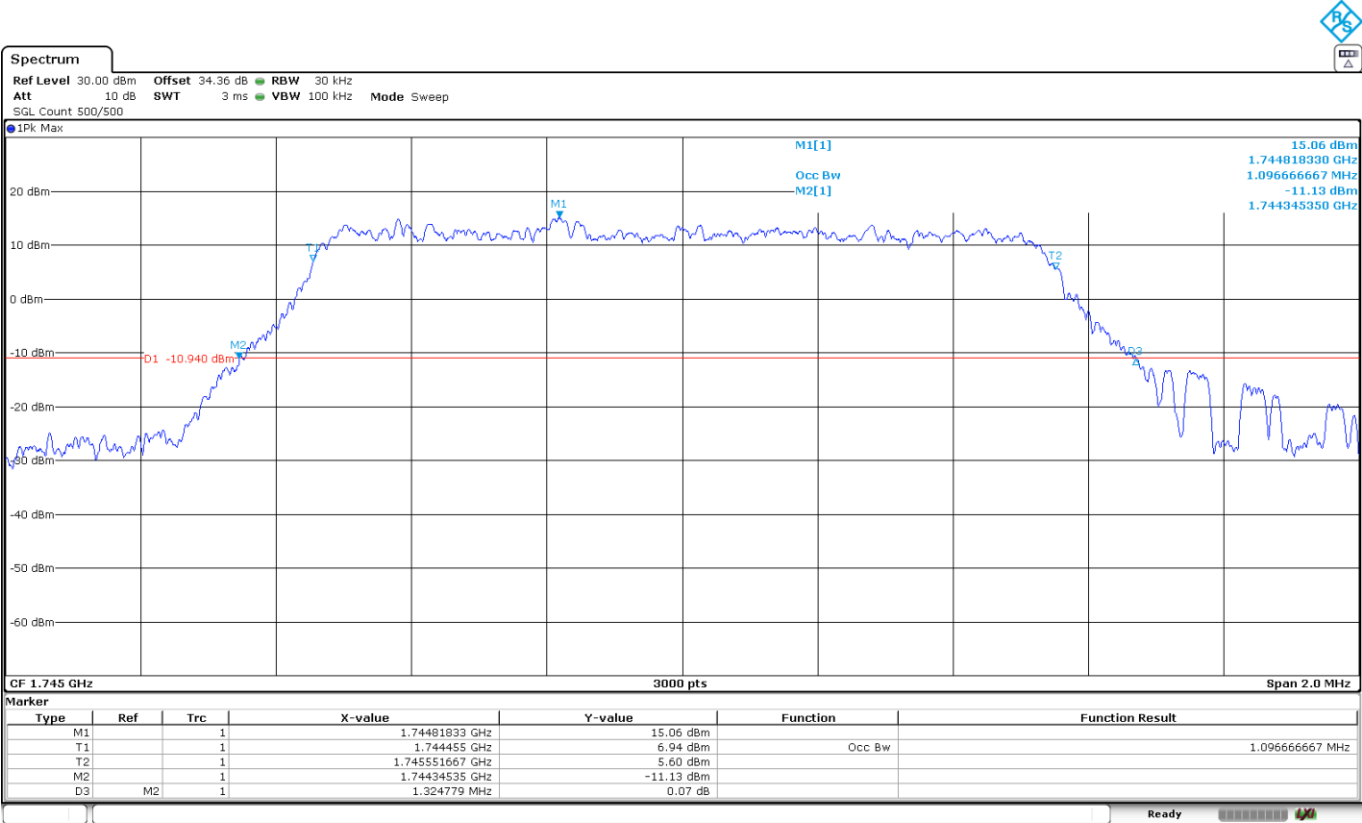


LTE Cat-M1 Band 66. BW=1.4 MHz. QPSK. RB Size 6.

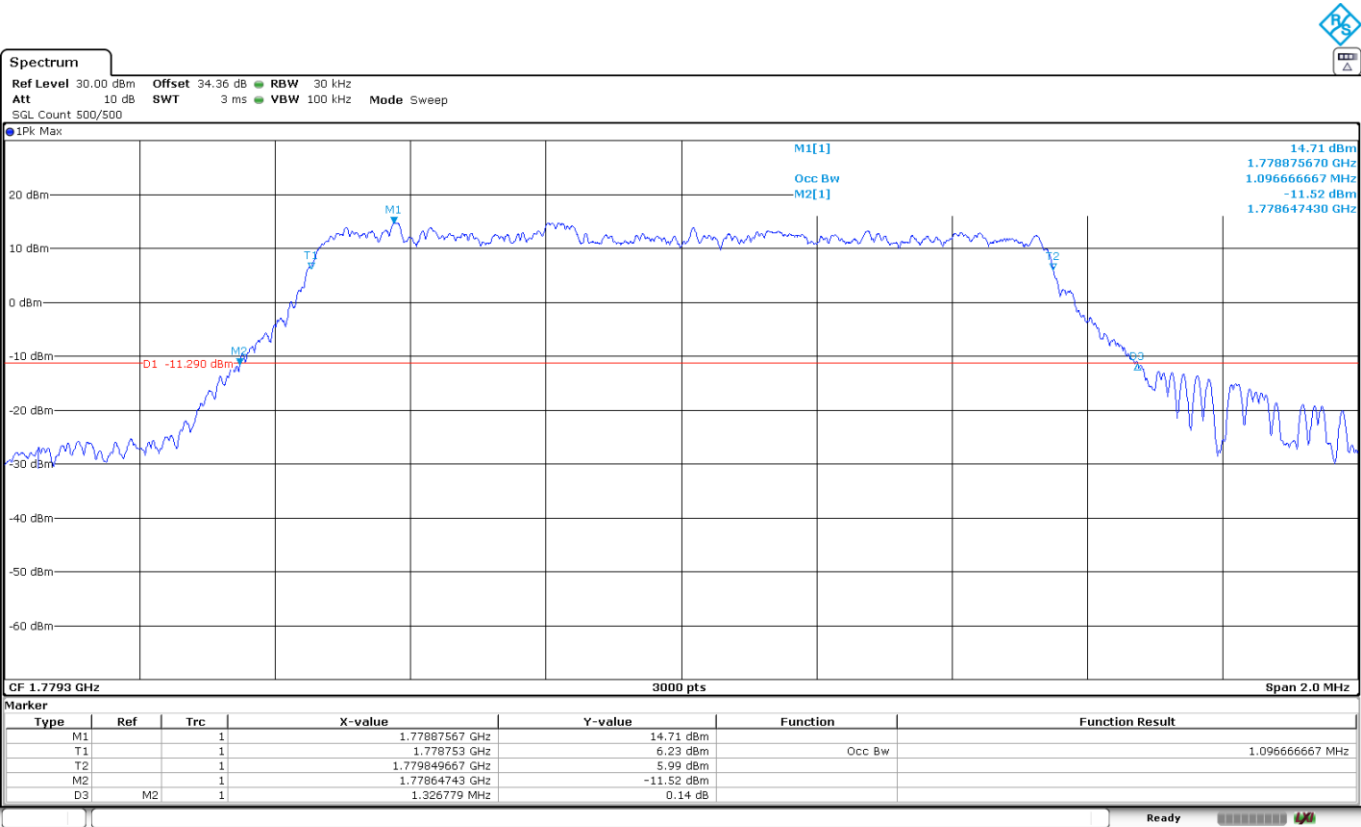
Low Channel:



Middle Channel:

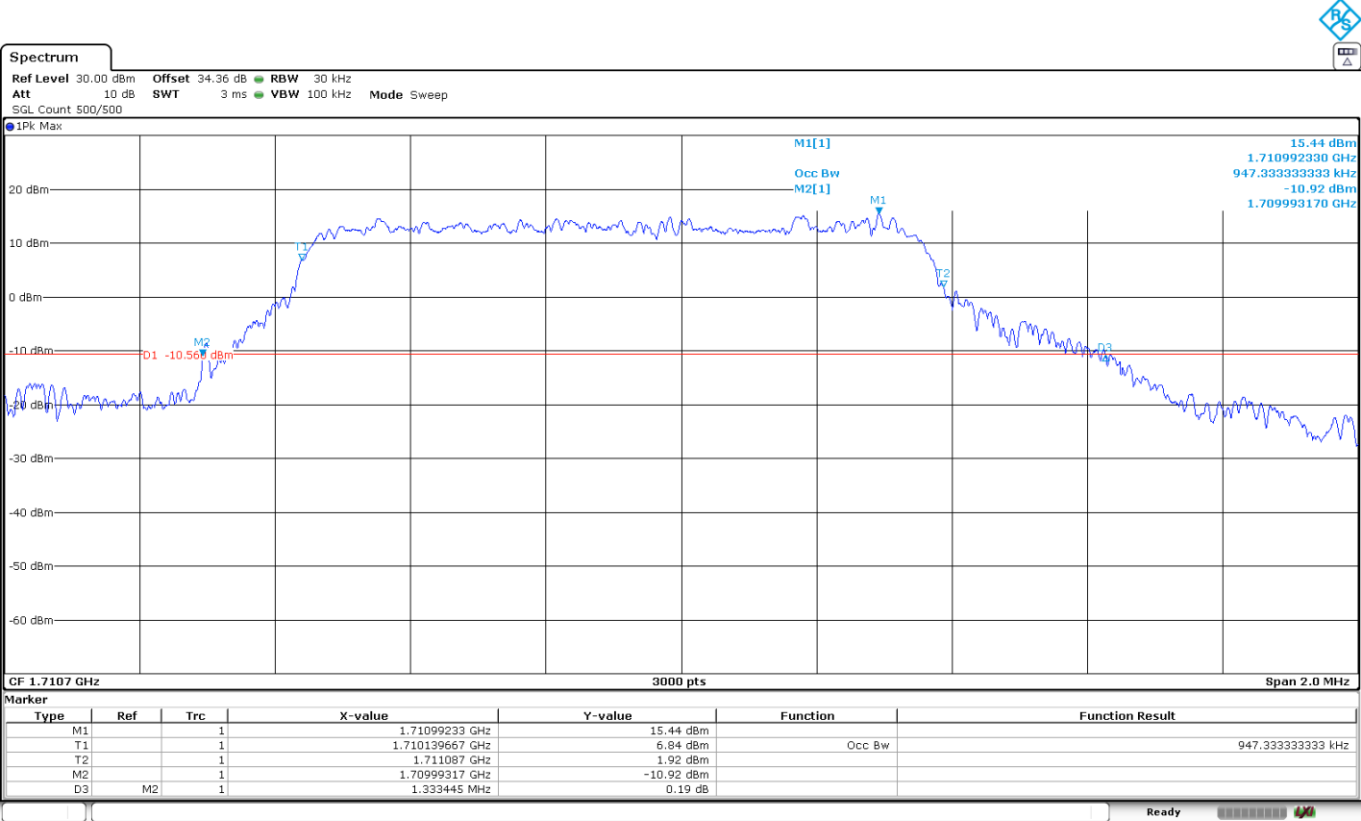


High Channel:

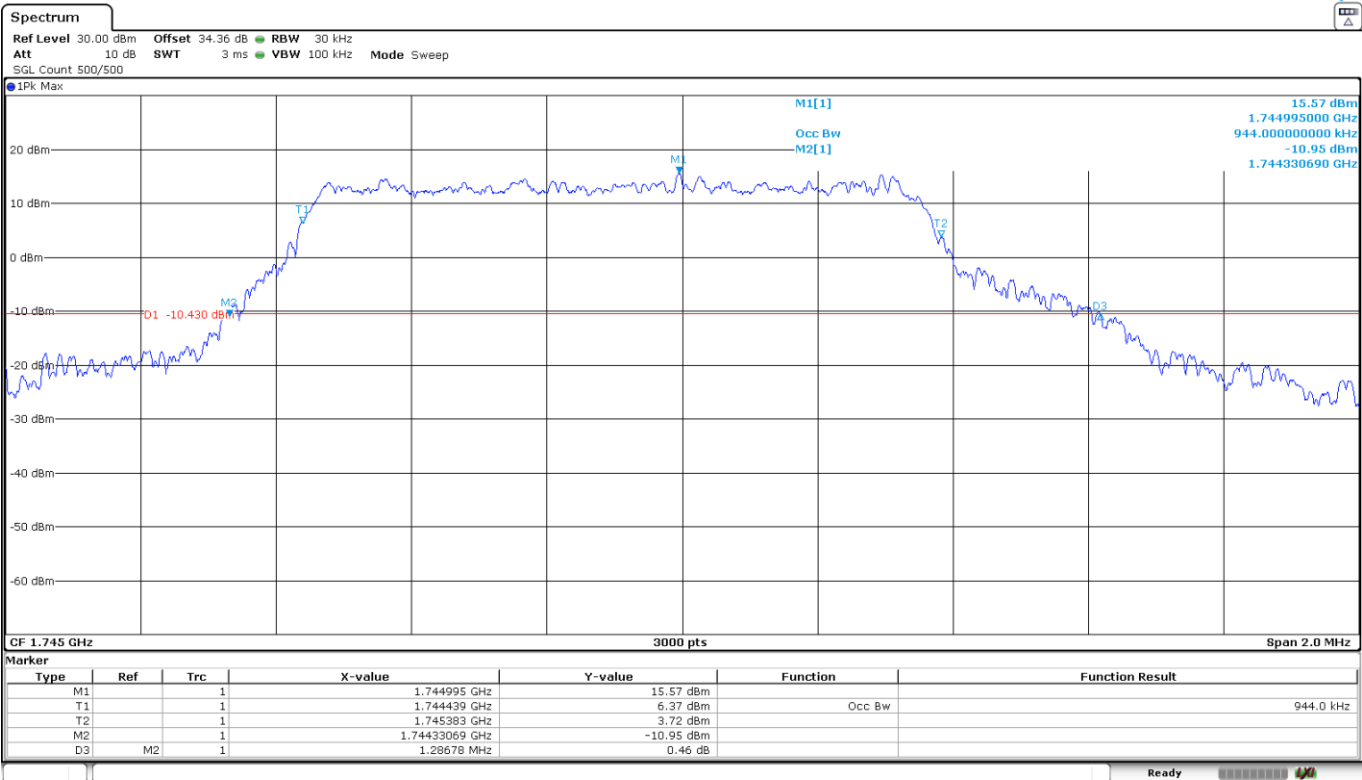


LTE Cat-M1 Band 66. BW=1.4 MHz. 16QAM. RB Size 5.

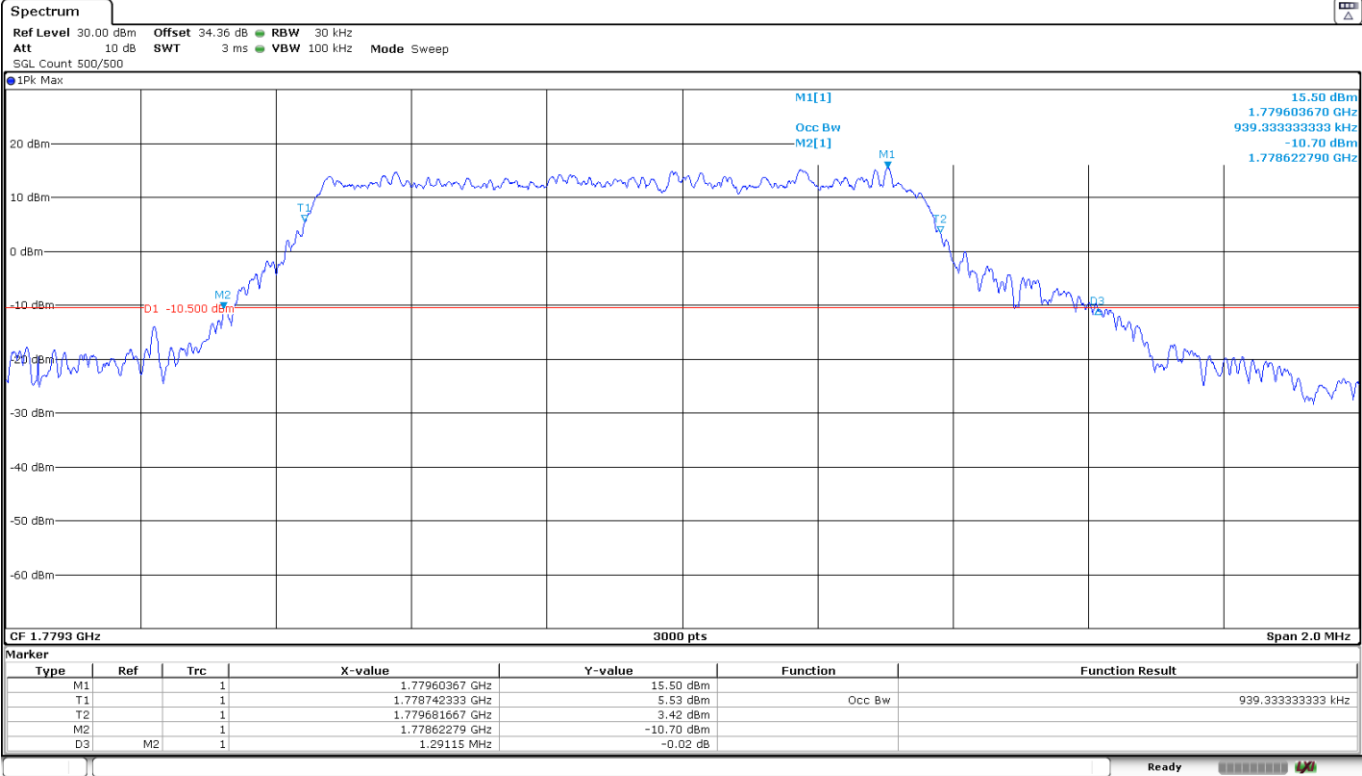
Low Channel:



Middle Channel:

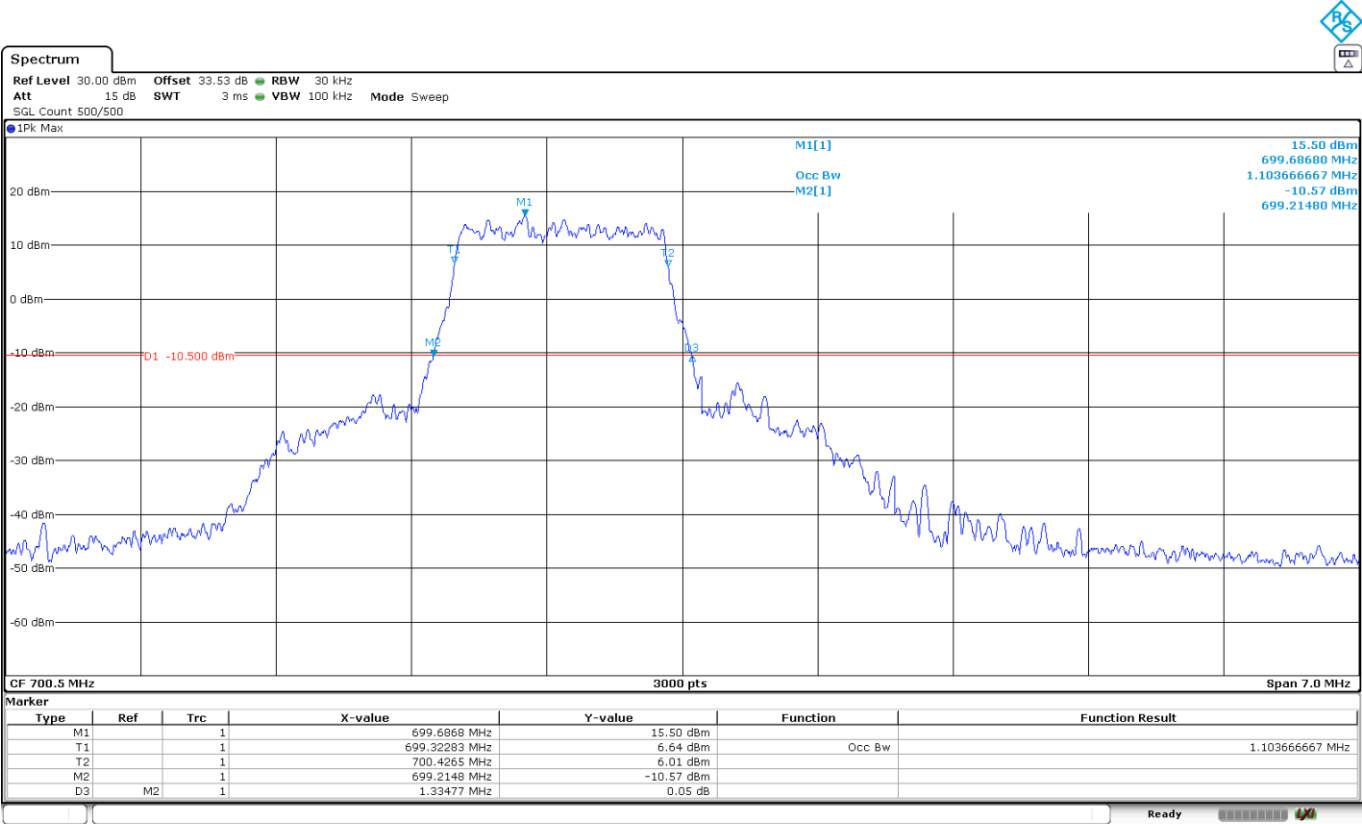


High Channel:

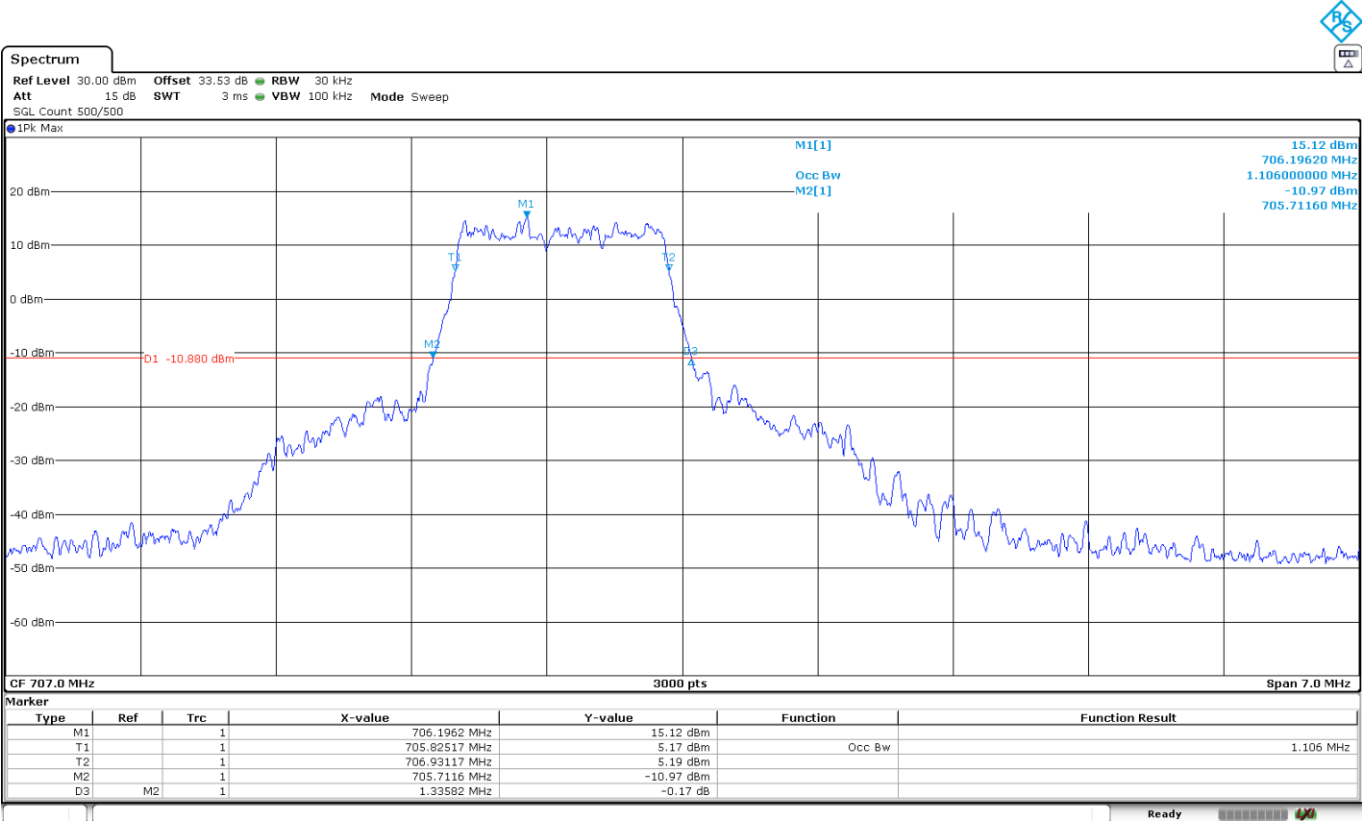


LTE Cat-M1 Band 85. BW=5 MHz. QPSK. RB Size 6.

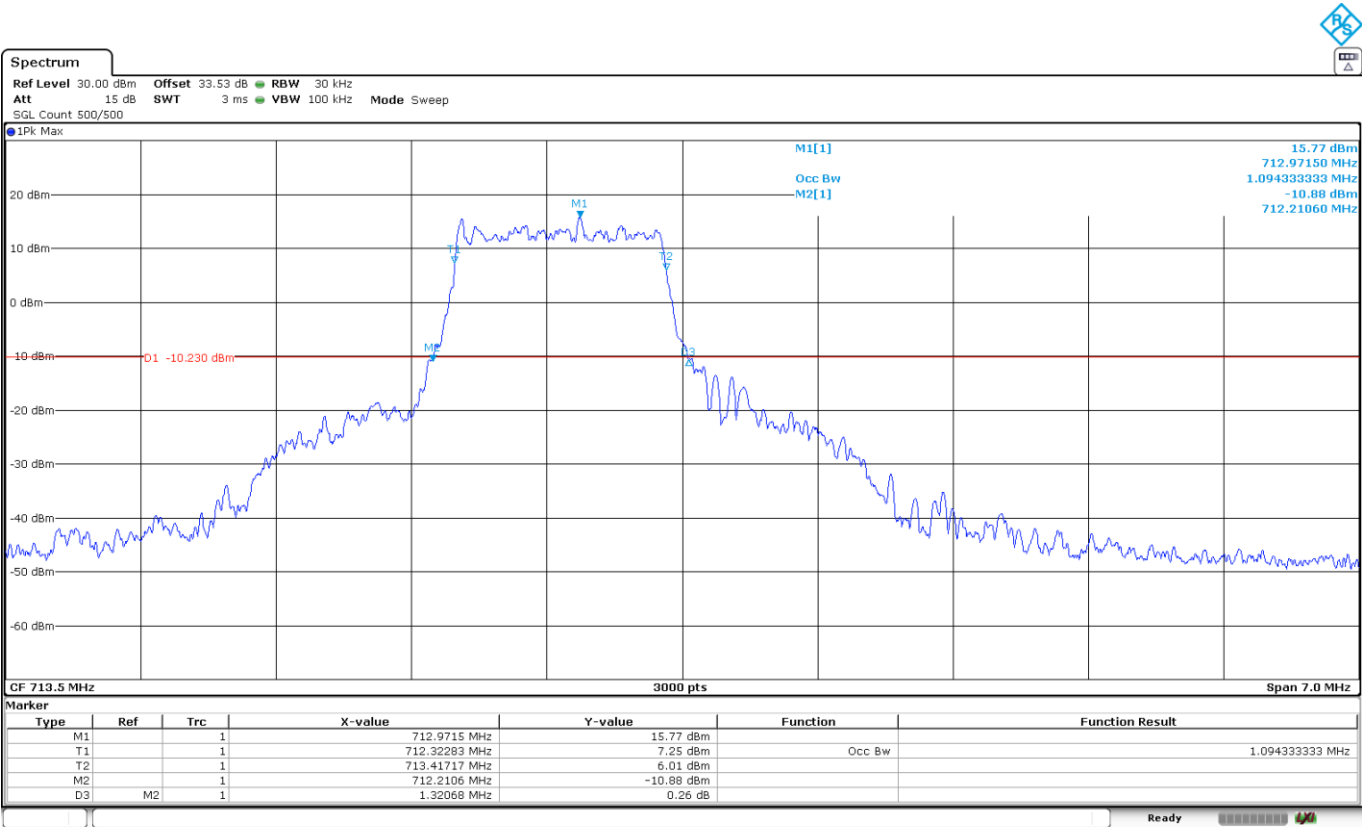
Low Channel:



Middle Channel:

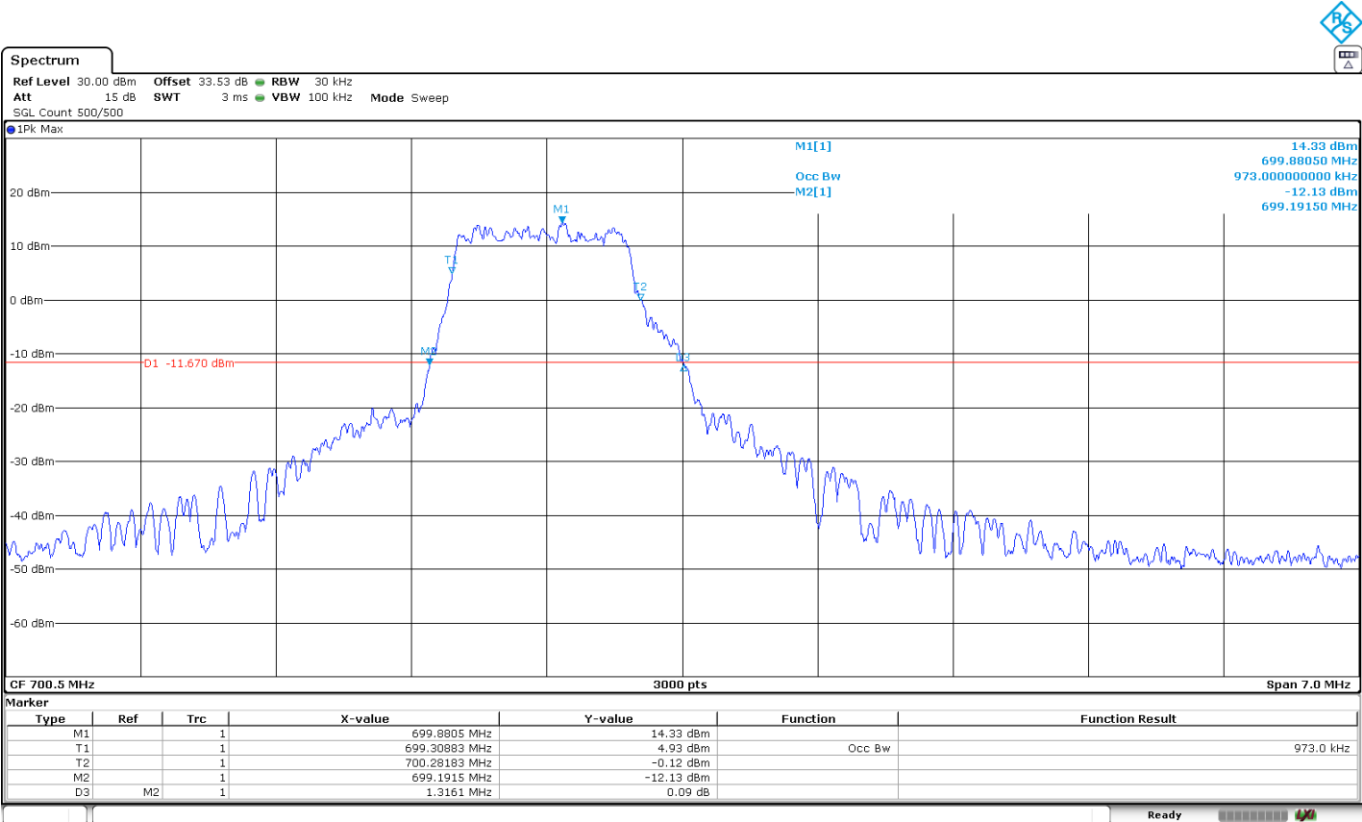


High Channel:

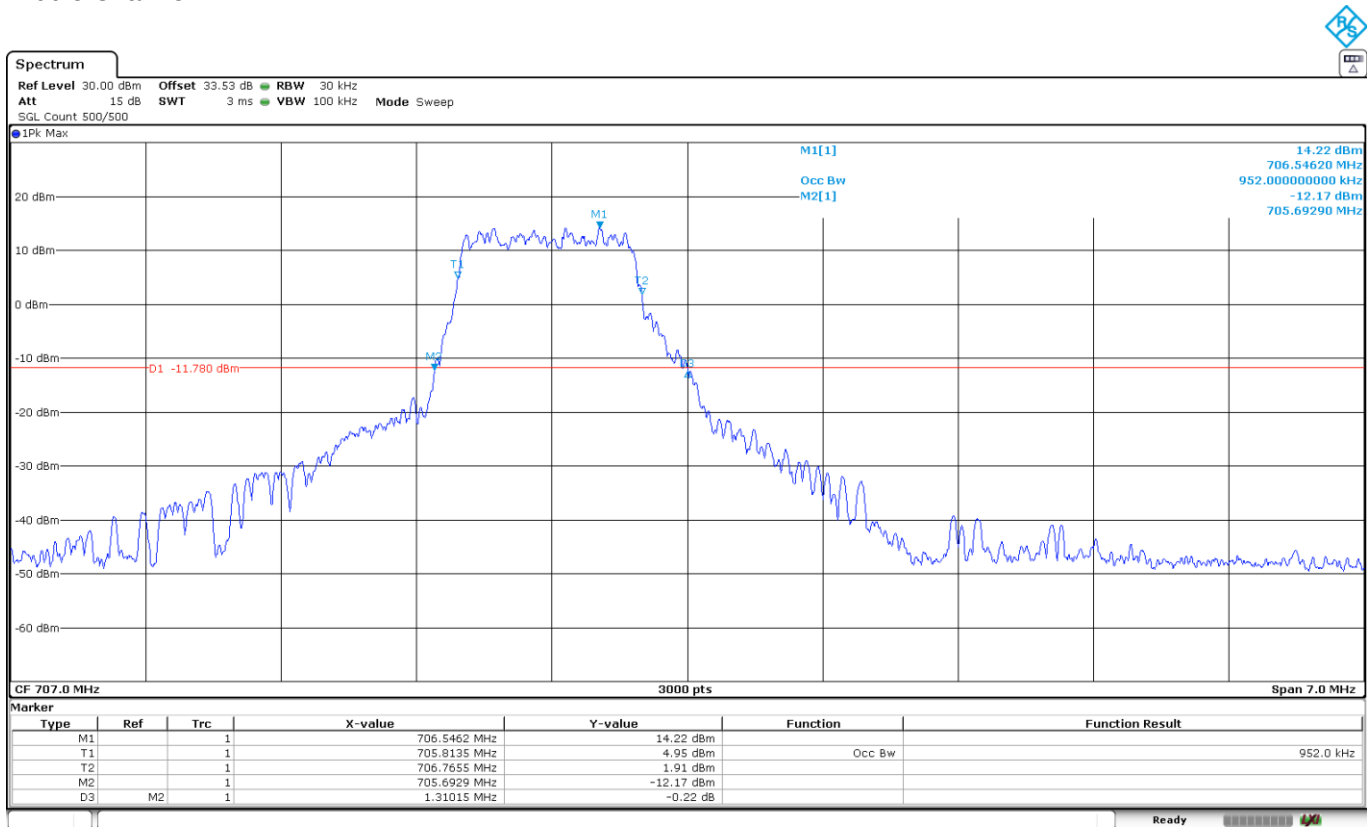


LTE Cat-M1 Band 85. BW=5 MHz. 16QAM. RB Size 5.

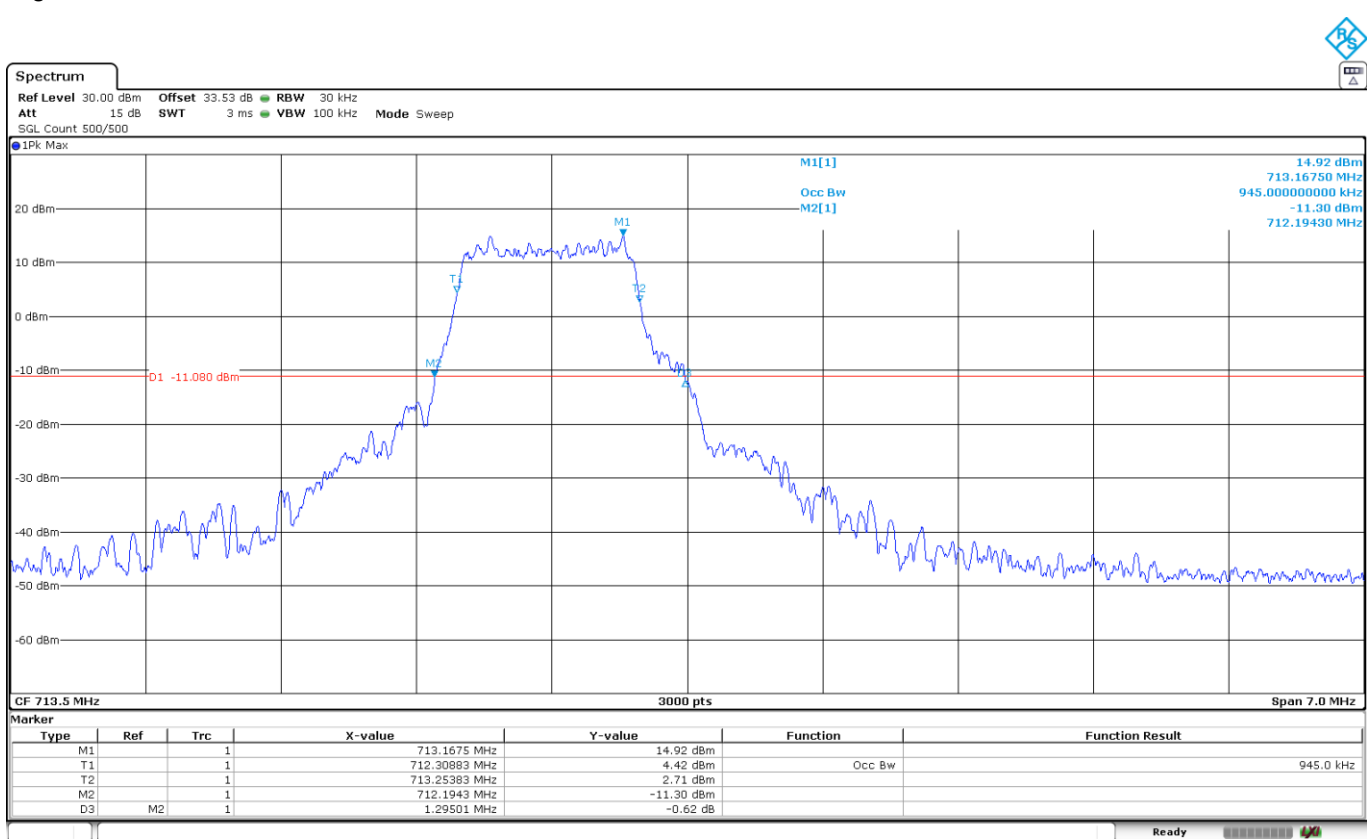
Low Channel:



Middle Channel:



High Channel:



## Spurious Emissions at Antenna Terminals

### Limits

#### 1. LTE Cat-M1 Band 8. FCC §27.1509 (a).

FCC §27.1509 (a):

The power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) in watts by at least the following amounts:

- (a) For 900 MHz broadband operations in 897.5–900.5 MHz band by at least  $43 + 10 \log (P)$  dB.

#### 2. LTE Cat-M1 Band 13.

FCC §27.53 (c):

On any frequency outside the 776-788 MHz band. the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least  $43 + 10 \log (P)$  dB. Compliance is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kHz or greater.

On all frequencies between 763-775 MHz and 793-805 MHz. by a factor not less than  $65 + 10 \log (P)$  dB in a 6.25 kHz band segment. for mobile and portable stations. Compliance is based on the use of measurement instrumentation such that the reading taken with any resolution bandwidth setting should be adjusted to indicate spectral energy in a 6.25 kHz segment.

RSS-130 4.7.1 and 4.7.2:

##### 4.7.1 General unwanted emissions limits:

The unwanted emissions in any 100 kHz bandwidth on any frequency outside the low frequency edge and the high frequency edge of each frequency block range(s), shall be attenuated below the transmitter power, P (dBW), by at least  $43 + 10 \log_{10} p$  (watts), dB. However, in the 100 kHz band immediately outside of the equipment's frequency block range, a resolution bandwidth of 30 kHz may be employed.

##### 4.7.2 Additional unwanted emissions limits:

In addition to the limit outlined in section 4.7.1 above, equipment operating in the frequency bands 746-756 MHz and 777-787 MHz shall also comply with the following restrictions:

a. the power of any unwanted emissions in any 6.25 kHz bandwidth for all frequencies between 763-775 MHz and 793-806 MHz shall be attenuated below the transmitter power, P (dBW), by at least:

- i.  $76 + 10 \log_{10} p$  (watts), dB, for base and fixed equipment and
- ii.  $65 + 10 \log_{10} p$  (watts), dB, for mobile and portable equipment

b. the e.i.r.p. in the band 1559-1610 MHz shall not exceed  $-70$  dBW/MHz for wideband signal and  $-80$  dBW for discrete emission with bandwidth less than 700 Hz.

#### 3. LTE Cat-M1 Band 66.

FCC §27.53 (h). RSS-139 5.6:

Unwanted emissions shall be measured in terms of average values.

For all equipment, the TRP or total conducted power (sum of conducted power across all antenna connectors) of the unwanted emissions outside the frequency block or frequency block group shall not exceed the limits shown in table 6.

| Table 6: Unwanted emission limits                                    |                          |
|----------------------------------------------------------------------|--------------------------|
| Offset from the edge of the frequency block or frequency block group | Unwanted emission limits |
| 1 MHz                                                                | -13 dBm/(1% of OB*)      |
| >1 MHz                                                               | -13 dBm/MHz              |

\*OB is the occupied bandwidth.

In addition to complying with the above limits, equipment operating in the band 2180-2200 MHz may require additional filtering (see SRSP-519).

#### 4. LTE Cat-M1 Band 85.

FCC §27.53 (g):

For operations in the 600 MHz band and the 698-746 MHz band. the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation. measured in watts. by at least  $43 + 10 \log (P)$  dB. Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kilohertz or greater.

RSS-130. Clause 4.7.1:

The unwanted emissions in any 100 kHz bandwidth on any frequency outside the low frequency edge and the high frequency edge of each frequency block range(s). shall be attenuated below the transmitter power. P (dBW). by at least  $43 + 10 \log_{10} p$  (watts). 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:

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

At  $P_o$  transmitting power. the specified minimum attenuation becomes  $65+10 \log (P_o)$ . and the level in dBm relative to  $P_o$  becomes:

$$P_o \text{ (dBm)} - [65 + 10 \log (P_o \text{ in mW}) - 30] = -35 \text{ dBm}$$

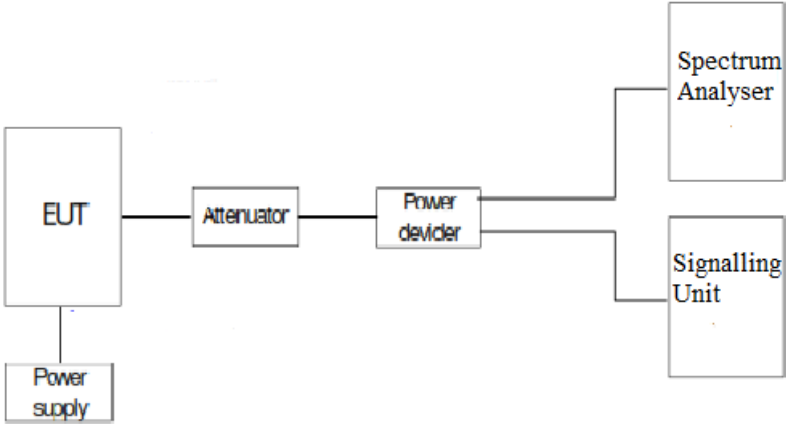
#### Method

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 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 Cat-M1 Band 8:** BW=1.4 MHz. QPSK. RB Size 1. RB Offset 2. Narrowband 0.

- Low 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

**LTE Cat-M1 Band 13:** BW=5 MHz. QPSK. RB Size 1. RB Offset 0. Narrowband 0.

- Low Channel: Spurious frequencies at less than 20 dB below the limit:

| Spurious Frequency (MHz) | Emission Limitations Conducted (dBm) | Limit (dBm) |
|--------------------------|--------------------------------------|-------------|
| 774.777143               | -50.04                               | -35         |

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

**LTE Cat-M1 Band 66:** BW=15 MHz. QPSK. RB Size 6. RB Offset 0. Narrowband 0.

- 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.

**LTE Cat-M1 Band 85:** BW=5 MHz. QPSK. RB Size 1. RB Offset 2. Narrowband 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): <±2.76

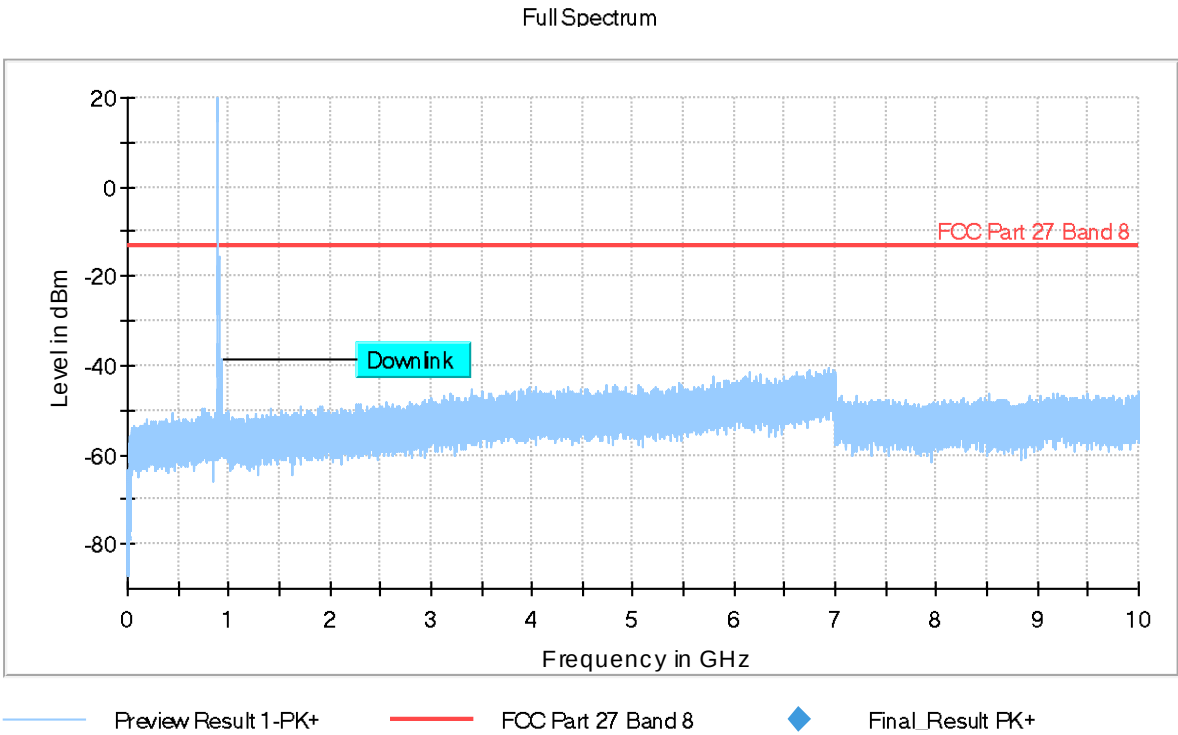
Verdict

PASS

| Subrange         | Step Size  | Detectors | Bandwidth | Sweep Time | Preamp |
|------------------|------------|-----------|-----------|------------|--------|
| 9 kHz - 150 kHz  | 14.1 Hz    | PK+       | 300 Hz    | Coupled    | 0 dB   |
| 150 kHz - 30 MHz | 932.812 Hz | PK+       | 10 kHz    | Coupled    | 0 dB   |
| 30 MHz - 1 GHz   | 30.312 kHz | PK+       | 100 kHz   | Coupled    | 0 dB   |
| 1 GHz - 2 GHz    | 31.25 kHz  | PK+       | 100 kHz   | Coupled    | 0 dB   |
| 2 GHz - 3 GHz    | 31.25 kHz  | PK+       | 100 kHz   | Coupled    | 0 dB   |
| 3 GHz - 4 GHz    | 31.25 kHz  | PK+       | 100 kHz   | Coupled    | 0 dB   |
| 4 GHz - 5 GHz    | 31.25 kHz  | PK+       | 100 kHz   | Coupled    | 0 dB   |
| 5 GHz - 6 GHz    | 31.25 kHz  | PK+       | 100 kHz   | Coupled    | 0 dB   |
| 6 GHz - 7 GHz    | 31.25 kHz  | PK+       | 100 kHz   | Coupled    | 0 dB   |
| 7 GHz - 8 GHz    | 31.25 kHz  | PK+       | 100 kHz   | Coupled    | 0 dB   |
| 8 GHz - 9 GHz    | 31.25 kHz  | PK+       | 100 kHz   | Coupled    | 0 dB   |
| 9 GHz - 10 GHz   | 31.25 kHz  | PK+       | 100 kHz   | Coupled    | 0 dB   |

LTE Cat-M1 Band 8. BW=1.4 MHz. QPSK. RB Size 1. RB Offset 2. Narrowband 0.

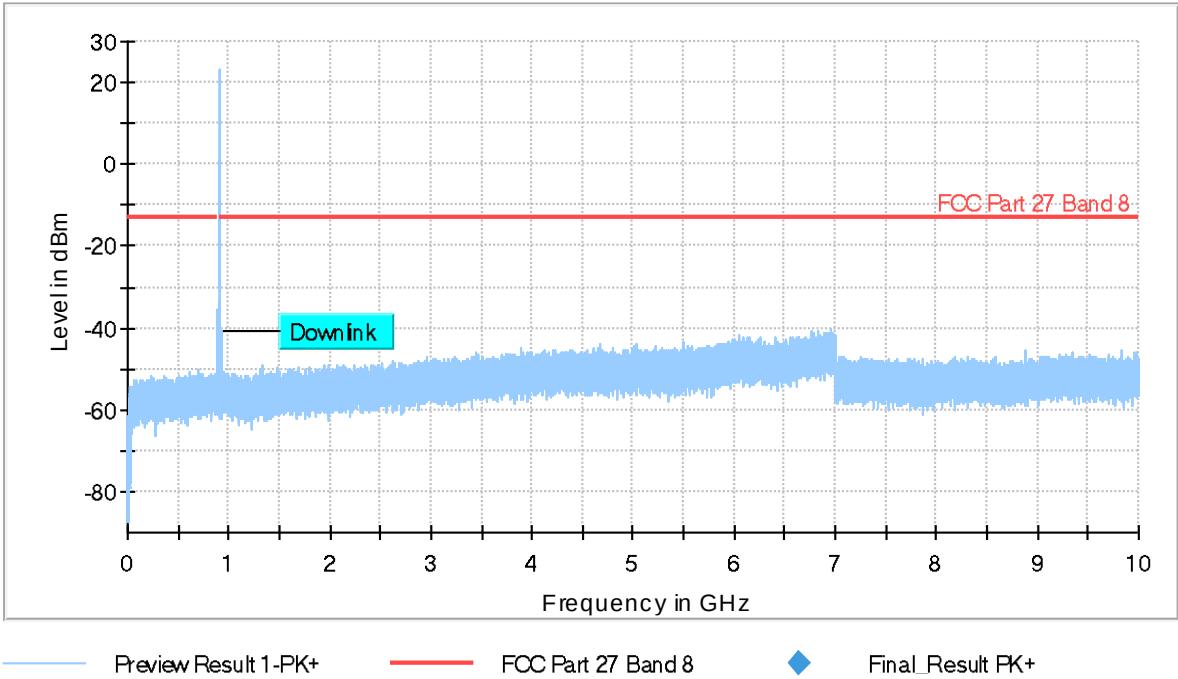
Low Channel:



The peak above the limit is the carrier frequency.  
The highest peak next to the carrier is the Downlink frequency.

High Channel:

Full Spectrum



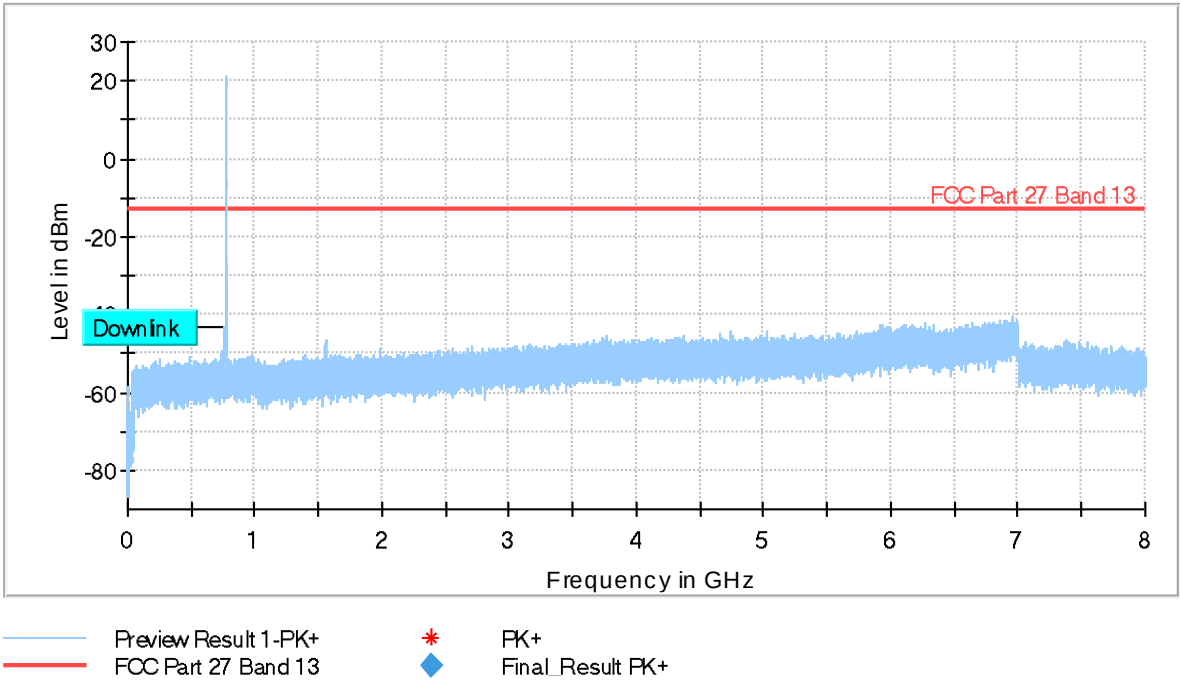
The peak above the limit is the carrier frequency.  
The highest peak next to the carrier is the Downlink frequency.

LTE Cat-M1 Band 13. BW=5 MHz. QPSK. RB Size 1. RB Offset 0. Narrowband 0.

Low Channel:

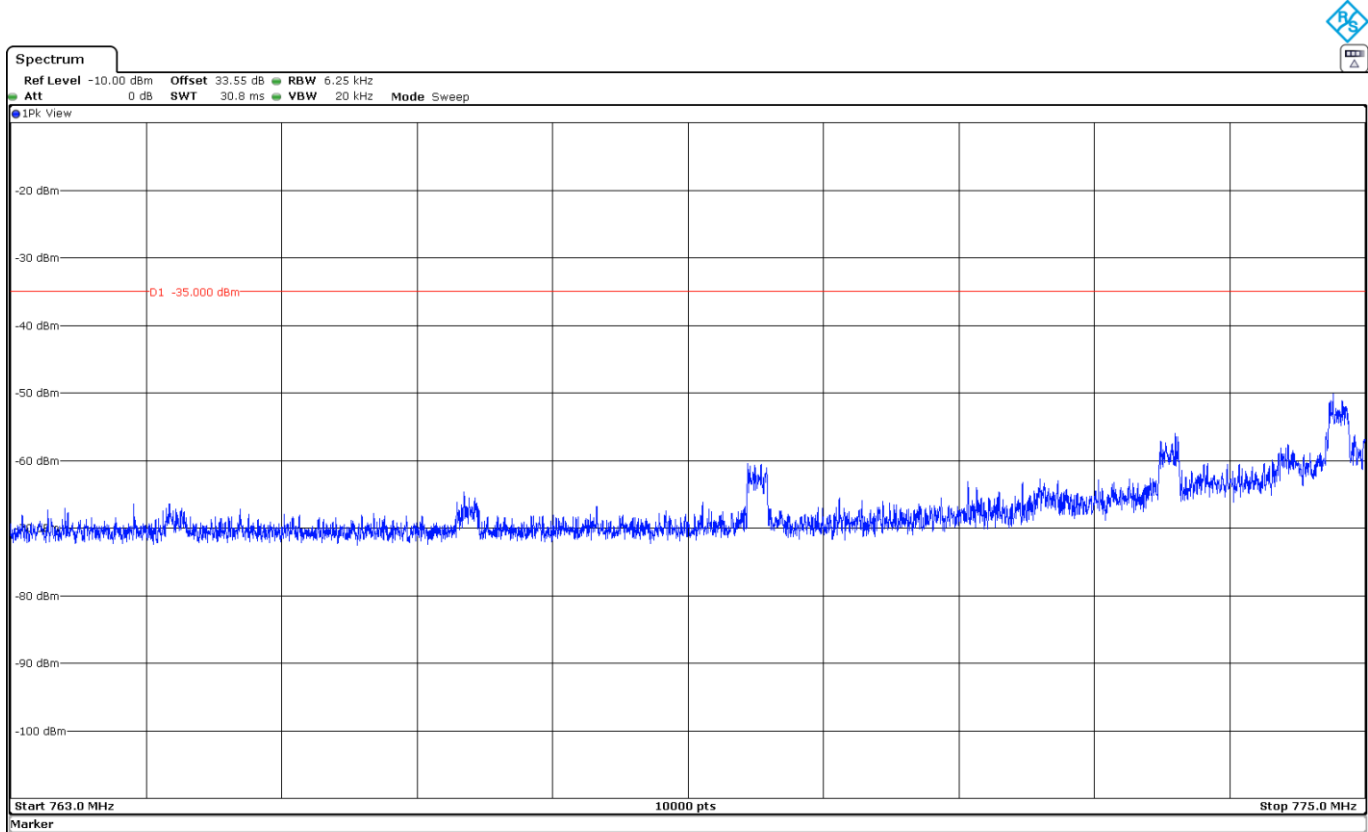
- Frequency range 9 kHz – 8 GHz:

Full Spectrum



The peak above the limit is the carrier frequency.  
The highest peak next to the carrier is the Downlink frequency.

- Frequency range 763 MHz – 775 MHz:



- Frequency range 793 MHz – 806 MHz:

