**DEKRA Testing and Certification, S.A.U.**
Parque Tecnológico de Andalucía,
c/ Severo Ochoa nº 2 · 29590 Campanillas · Málaga · España
C.I.F. A29507456

Test Report No:
72148RRF.001A3

# Test Report
## USA FCC Part 27

| | |
|---|---|
| (*) Identification of item tested | nRF91 |
| (*) Trademark | nRF91 |
| (*) Model and /or type reference | nrRF9160 |
| Other identification of the product | FCC ID: 2ANPO00NRF9160<br>IC: 24529-NRF9160 |
| (*) Features | Features: LTE Cat-M1, LTE-NB1<br>HW version: nRF9160-SICA-B1A<br>SW version: mfw_nRF9160_1.3.2 |
| Applicant | NORDIC SEMICONDUCTOR ASA<br>Otto Nielsens Vel 12<br>7052 Trondheim, Norway |
| Test method requested, standard | USA FCC Part 27 (10-1-21 Edition).<br>ANSI C63.26-2015.<br>ANSI/TIA-603-E: 2016.<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<br>Firmado digitalmente por 53680346W JOSE MANUEL GOMEZ (C:A29507456) |
| Date of issue | 2023-05-31 |
| Report template No | FDT08_24<br>(*) “Data provided by the client” |

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# Competences and guarantees

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

DEKRA Testing and Certification is a FCC-recognized accredited testing laboratory with appropriate scope of accreditation that include testing performed in this test report.

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

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

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# General conditions

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2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
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# Uncertainty

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

# Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested").

2. The sample of the model nRF91 consist in a Development Kit that has nRF9160 IOT Module and nRF52840 BTLE SoC. The nRF9160 is capable of LTE Cat-M1, Cat-NB1 and GPS. The Development kit has LTE, GPS and BTLE Antennas included.

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 | Serial Nº | Date of Reception | Application |
|---|---|---|---|---|---|---|
| S/01 & S/02 | 72148_1.1 | Development Kit | nRF9160 | 351358811330114 | 2022-05-10 | Element Under Test |
| S/02 | 72148_4.1 | SMA cable | -- | -- | 2022-05-10 | Auxiliary Element |

Notes referenced to samples during the project:

| Id | Type |
|---|---|
| S/01 | Sample used for radiated test |
| S/02 | Sample used for conducted test |

# Test sample description

| | | | | | |
|---|---|---|---|---|---|
| Ports……: | Port name and description | Cable | | | |
| | | Specified max length [m] | Attached during test | Shielded | Coupled to patient(3) |
| | LTE RF | 2 | ☒ | ☒ | ☐ |
| | GPS | 2 | ☐ | ☐ | ☐ |
| | BTLE | | ☐ | ☐ | ☐ |
| | -- | | ☐ | ☐ | ☐ |
| Supplementary information to the ports…… : | - | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Rated power supply ..... : | Voltage and Frequency | | Reference poles | | | | |
| | | | L1 | L2 | L3 | N | PE |
| | ☐ | AC: | ☐ | ☐ | ☐ | ☐ | ☐ |
| | ☐ | AC: | ☐ | ☐ | ☐ | ☐ | ☐ |
| | ☒ | DC: 3.0 - 5.5 V | | | | | |
| | ☐ | DC: | | | | | |

| | |
|---|---|
| Rated Power..... : | 1W |
| Clock frequencies..... : | 32KHz, 32MHz |
| Other parameters ..... : | - |
| Software version..... : | mfw_nRF9160_1.3.2 |
| Hardware version ..... : | nRF9160-SICA-B1A |
| Dimensions in cm (W x H x D) ... : | 15.5x6.4x0.9 |

| | | |
|---|---|---|
| Mounting position ..... : | ☒ | Table top equipment |
| | ☐ | Wall/Ceiling mounted equipment |
| | ☐ | Floor standing equipment |
| | ☐ | Hand-held equipment |
| | ☐ | 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 |
| | - | | |
| | - | | |

(3) Only for Medical Equipment

# Identification of the client

NORDIC SEMICONDUCTOR ASA
Otto Nielsens Vei 12
7052 Trondheim, Norway

# Testing period and place

| | |
|---|---|
| **Test Location** | DEKRA Testing and Certification S.A.U. |
| **Date (start)** | 2022-08-29 |
| **Date (finish)** | 2022-01-25 |

# Document history

| Report number | Date | Description |
|---|---|---|
| 72148RRF.001 | 2022-11-08 | First release. |
| 72148RRF.001A1 | 2023-02-14 | It includes conducted testing.<br>This modification test report cancels and replaces the test report 72148RRF.001. |
| 72148RRF.001A2 | 2023-03-29 | It has been corrected some minor typos<br>This modification test report cancels and replaces the test report 72148RRF.001A1. |
| 72148RRF.001A3 | 2023-05-31 | It has been corrected the lowest and highest frequency channels for NBIoT.<br>This modification test report cancels and replaces the test report 72148RRF.001A2. |

# Environmental conditions

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

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

In the semianechoic chamber, the following limits were not exceeded during the test.

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

# Remarks and comments

The tests have been performed by the technical personnel: Miguel Manuel López, Rafael Fernandez, Francisco Javier Fernández and Pablo Redondo.

Used instrumentation:

| Control No. | Equipment | Model | Manufacturer | Next Calibration |
|---|---|---|---|---|
| 6791 | SEMIANECHOIC ABSORBER LINED CHAMBER IV | FACT 3 200 STP | ETS LINDGREN | N/A |
| 6792 | SHIELDED ROOM | S101 | ETS LINDGREN | N/A |
| 7817 | EMI TEST RECEIVER 2Hz-44GHz | ESW44 | ROHDE AND SCHWARZ | 2023-12-30 |
| 6496 | HORN ANTENNA 1-18GHz | BBHA 9120 D | SCHWARZBECK | 2023-08-24 |
| 6143 | HYBRID BILOG ANTENNA 30MHz-6GHz | 3142E | ETS LINDGREN | 2023-10-29 |
| 3783 | PRE-AMPLIFIER G>30dB 1GHz-18GHz | BLMA 0118-3A | BONN ELEKTRONIK | 2023-12-29 |
| 7445 | DC POWER SUPPLY 30V/5A | U8002A | KEYSIGHT TECHNOLOGIES | N/A |
| 7760 | DIGITAL MULTIMETER | 175 | FLUKE | 2023-11-14 |
| 4848 | SOFTWARE FOR EMC/RF TESTING | EMC32 | ROHDE AND SCHWARZ | N/A |
| 7794 | SIGNAL AND SPECTRUM ANALYZER 10Hz-40GHz | FSV40 | ROHDE AND SCHWARZ | 2025-04-21 |
| 5393 | SIGNAL ANALYSER 20Hz-8GHz | FSQ8 | ROHDE AND SCHWARZ | 2023-11-03 |
| 6667 | WIDEBAND RADIO COMMUNICATION TESTER | CMW500 | ROHDE AND SCHWARZ | 2023-05-31 |

# Testing verdicts

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

# Summary

| FCC PART 27 PARAGRAPH | | |
|---|---|---|
| **Requirement – Test case** | **Verdict** | **Remark** |
| FCC 27.1507: RF Output Power | P | -- |
| FCC 2.1047: Modulation Characteristics | P | -- |
| FCC 27.54: Frequency Stability | P | -- |
| FCC 2.1049: Occupied Bandwidth | P | -- |
| FCC 27.1509: Spurious Emissions at Antenna Terminals | P | -- |
| FCC 27.1509: Spurious emissions at antenna terminals at Block Edges | P | -- |
| FCC 27.1509: Radiated Emissions | P | -- |
| Supplementary information and remarks:<br>None. | | |

# **Appendix A:** Test results for FCC 27

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# TEST CONDITIONS

(*): Data provided the Applicant.

POWER SUPPLY (*):

Vnominal: 5Vdc

Vmin: 3Vdc

Vmax: 5.5Vdc

Type of Power Supply: DC external supply.

ANTENNA (*):

| BAND | GAIN | ANTENNA TYPE |
|---|---|---|
| LTE Cat. M1 Band 8 | +2.7 dBi | SMD |
| LTE NB-IoT Band 8 | +2.7 dBi | SMD |

TEST FREQUENCIES (*):

Operating broadband system: 897.5-900.5 MHz

LTE Cat M1 Band 8: QPSK and 16QAM Modulation:

| | Channel per Nominal Bandwidth (Frequency MHz) | | | |
|---|---|---|---|---|
| | BW = 1.4 MHz | BW = 3 MHz | BW = 5 MHz | BW = 10 MHz |
| Low | 21632 (898.2) | | | |
| Middle | 21645 (899.5) | | | |
| High | 21648 (899.8) | | | |

LTE NB-IoT Band 8. Pi/2-BPSK and pi/4-QPSK Modulation:

| | Channel Number (Frequency MHz) | |
|---|---|---|
| | Tone Channel BW = 3.75 kHz | Tone Channel BW = 15 kHz |
| Low | 21628 (897.8)* | |
| Middle | 21645 (899.5) | |
| High | 21652 (900.2)* | |
| **The outermost channel which is in compliance with Block edge testing.* | | |

# RF Output Power

SPECIFICATION:

FCC Subpart P §27.1507 (a):

**(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.

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

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

METHOD:

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

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

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

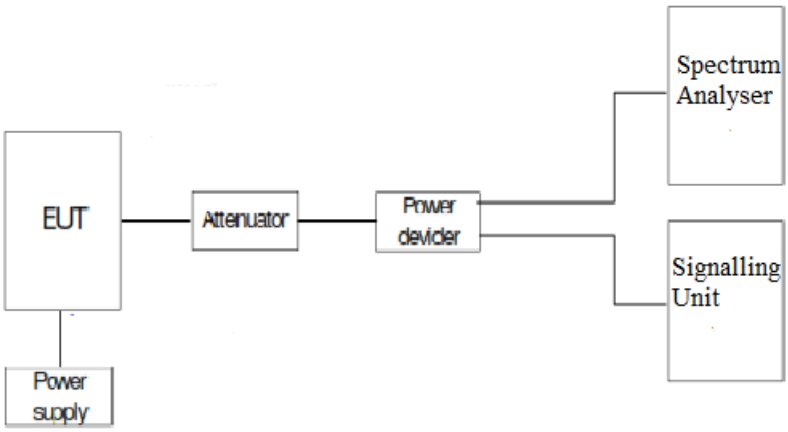
E.R.P. = E.I.R.P. – 2.15 dB

The peak-to-average power ratio (PAPR) is measured using an attenuator, power splitter and spectrum analyser with a Complementary Cumulative Distribution Function implemented.
The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

TEST SETUP:

1. CONDUCTED AVERAGE POWER:

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




RESULTS:

**1. AVERAGE POWER:**

LTE Cat. M1 Band 8

Preliminary measurements determined the narrow band = 0 and nominal bandwidth of 1.4 MHz as the worst case. The results in the next tables shows the results for this configuration.

Narrow band = 0

| BANDWIDTH (MHz) | CHANNEL | FREQUENCY (MHz) | MODULATION | RB SIZE | RB OFFSET | AVERAGE POWER (dBm) | PAPR (dB) |
|---|---|---|---|---|---|---|---|
| 1.4 | 21632 | 898.2 | QPSK | 1 | 2 | 22.86 | - |
| | | | | 6 | 0 | - | - |
| | | | 16-QAM | 1 | 2 | 21.91 | 6.65 |
| | | | | 5 | 1 | - | - |
| | 21645 | 899.5 | QPSK | 1 | 2 | 22.94 | 5.14 |
| | | | | 6 | 0 | 21.04 | 5.67 |
| | | | 16-QAM | 1 | 2 | 21.87 | 7.05 |
| | | | | 5 | 1 | 20.90 | 6.57 |
| | 21648 | 899.8 | QPSK | 1 | 2 | 22.90 | - |
| | | | | 6 | 0 | - | - |
| | | | 16-QAM | 1 | 2 | 21.92 | 6.68 |
| | | | | 5 | 1 | - | - |

Measurement uncertainty (dB): ±0.941

LTE Cat. M1 Band 8. QPSK MODULATION. Bandwidth = 1.4 MHz.

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| Maximum declared antenna gain (dBi) | 2.70 | 2.70 | 2.70 |
| Measured maximum average power (dBm) at antenna port | 22.86 | 22.94 | 22.90 |
| Maximum equivalent isotropically radiated power E.I.R.P. (dBm) | 25.56 | 25.64 | 25.60 |
| Maximum effective radiated power E.R.P. (dBm) | 23.41 | 23.49 | 23.45 |
| PAPR (dB) | (*) | 5.67 | (*) |
| Measurement uncertainty (dB) | ±0.941 | | |

Worst case AVERAGE POWER: Modulation QPSK. RB Size: 1. RB Offset: 2.

Worst case PAPR: Modulation QPSK. RB Size: 6. RB Offset: 0.

(*): Preliminary measurements determined the Middle Channel as the worst case.

LTE Cat. M1 Band 8. 16QAM MODULATION. Bandwidth = 1.4 MHz.

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| Maximum declared antenna gain (dBi) | 2.70 | 2.70 | 2.70 |
| Measured maximum average power (dBm) at antenna port | 21.91 | 21.87 | 21.92 |
| Maximum equivalent isotropically radiated power E.I.R.P. (dBm) | 24.61 | 24.57 | 24.62 |
| Maximum effective radiated power E.R.P. (dBm) | 22.46 | 22.42 | 22.47 |
| PAPR (dB) | 6.65 | 7.05 | 6.68 |
| Measurement uncertainty (dB) | ±0.941 | | |

Worst case AVERAGE POWER: Modulation 16QAM. RB Size: 1. RB Offset: 2.
Worst case PAPR: Modulation 16QAM. RB Size: 1. RB Offset: 2.

Verdict: Pass

LTE NB-IoT Band 8

| CHANNEL | FREQUENCY (MHz) | MODULATION | BW Tono | Number of Tone | Offset Tone (Start SubCarrier) | AVERAGE POWER (dBm) | PAPR (dB) |
|---|---|---|---|---|---|---|---|
| Low 21628 | 897.8 | pi/2-BPSK | 3.75 kHz | 1 | 0 | 22.12 | - |
| | | | | 1 | 47 | - | - |
| | | | 15 kHz | 1 | 0 | - | - |
| | | | | 1 | 11 | - | - |
| | | pi/4 - QPSK | 3.75 kHz | 1 | 0 | - | - |
| | | | | 1 | 47 | 21.95 | - |
| | | | 15 kHz | 1 | 0 | - | - |
| | | | | 1 | 11 | - | - |
| | | | | 3 | 0 | - | - |
| | | | | 3 | 9 | - | - |
| | | | | 6 | 0 | - | - |
| | | | | 6 | 6 | - | - |
| | | | | 12 | 0 | - | 4.42 |
| Middle 21645 | 899.5 | pi/2-BPSK | 3.75 kHz | 1 | 0 | 22.9 | 0.77 |
| | | | | 1 | 47 | 22.71 | 0.72 |
| | | | 15 kHz | 1 | 0 | 21.93 | 0.7 |
| | | | | 1 | 11 | 21.91 | 0.67 |
| | | pi/4 - QPSK | 3.75 kHz | 1 | 0 | 22.65 | 0.91 |
| | | | | 1 | 47 | 22.72 | 0.79 |
| | | | 15 kHz | 1 | 0 | 21.93 | 0.94 |
| | | | | 1 | 11 | 21.92 | 0.96 |
| | | | | 3 | 0 | 22.54 | 3.88 |
| | | | | 3 | 9 | 22.62 | 3.46 |
| | | | | 6 | 0 | 21.78 | 4.76 |
| | | | | 6 | 6 | 21.78 | 4.79 |
| | | | | 12 | 0 | 20.8 | 5 |
| High 21652 | 900.2 | pi/2-BPSK | 3.75 kHz | 1 | 0 | 22.01 | - |
| | | | | 1 | 47 | - | - |
| | | | 15 kHz | 1 | 0 | - | - |
| | | | | 1 | 11 | - | - |
| | | pi/4 - QPSK | 3.75 kHz | 1 | 0 | - | - |
| | | | | 1 | 47 | 22.066 | - |
| | | | 15 kHz | 1 | 0 | - | - |
| | | | | 1 | 11 | - | - |
| | | | | 3 | 0 | - | - |
| | | | | 3 | 9 | - | - |
| | | | | 6 | 0 | - | - |
| | | | | 6 | 6 | - | - |
| | | | | 12 | 0 | - | 4.29 |

Verdict: Pass

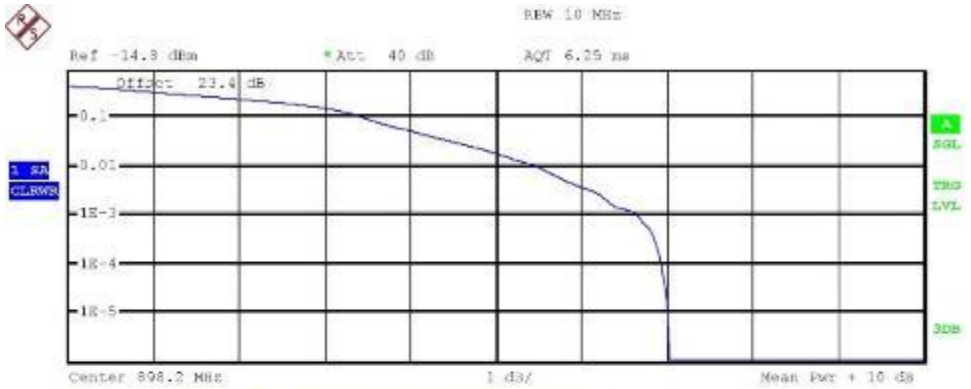
## 2. PEAK-TO-AVERAGE POWER RATIO (PAPR):

LTE Cat, M1 Band 8.

Preliminary measurements determined the narrow band = 0, nominal bandwidth of 1.4 MHz, 16-QAM modulation and 1 RB size offset 2 as the worst case. The results in the next tables shows the results for this configuration.

Bandwidth = 1.4 MHz. Modulation 16QAM. RB Size: 1. RB Offset: 2.

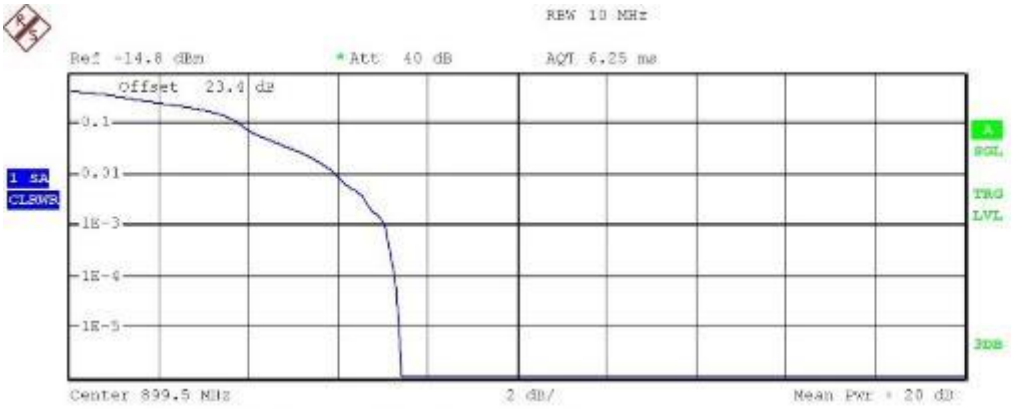
Lowest Channel:




**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 11.2MHz**

| | Trace 1 |
|---|---|
| Mean | 21.25 dBm |
| Peak | 28.27 dBm |
| Crest | 7.01 dB |
| 10 % | 3.48 dB |
| 1 % | 5.48 dB |
| .1 % | 6.65 dB |
| .01 % | 6.94 dB |

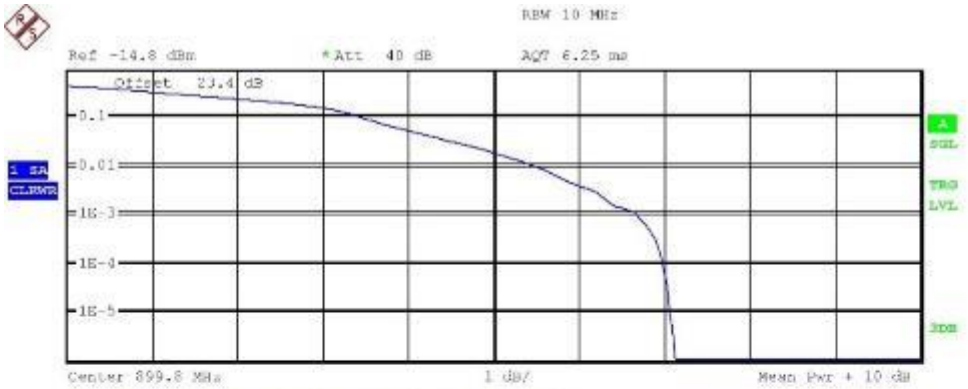
Middle Channel:




**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 11.2MHz**

| | Trace 1 |
|---|---|
| Mean | 21.33 dBm |
| Peak | 28.74 dBm |
| Crest | 7.40 dB |
| 10 % | 3.78 dB |
| 1 % | 5.96 dB |
| .1 % | 7.05 dB |
| .01 % | 7.28 dB |

Highest Channel:



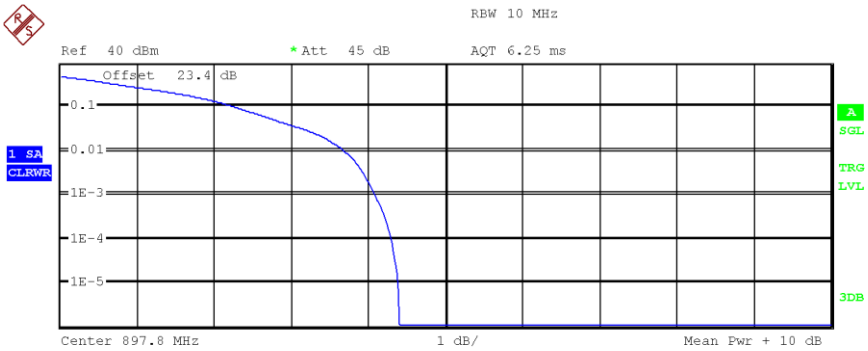

**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 11.2MHz**

| | Trace 1 |
|---|---|
| Mean | 21.22 dBm |
| Peak | 28.34 dBm |
| Crest | 7.12 dB |
| 10 % | 3.48 dB |
| 1 % | 5.50 dB |
| .1 % | 6.68 dB |
| .01 % | 6.99 dB |

LTE NB-IoT Band 8

Preliminary measurements determined that pi/4-QPSK modulation, 12 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

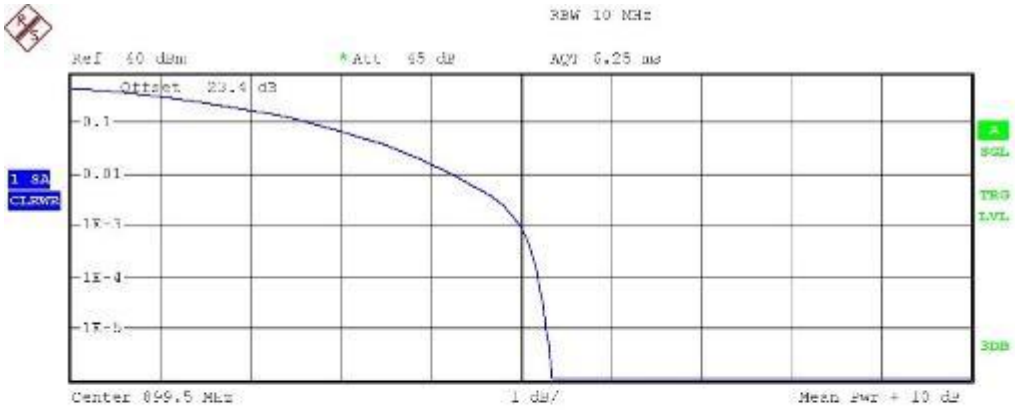
Lowest Channel:




**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 11.2MHz**

| | Trace 1 |
|---|---|
| Mean | 20.89 dBm |
| Peak | 25.29 dBm |
| Crest | 4.40 dB |
| 10 % | 2.28 dB |
| 1 % | 3.69 dB |
| .1 % | 4.09 dB |
| .01 % | 4.29 dB |

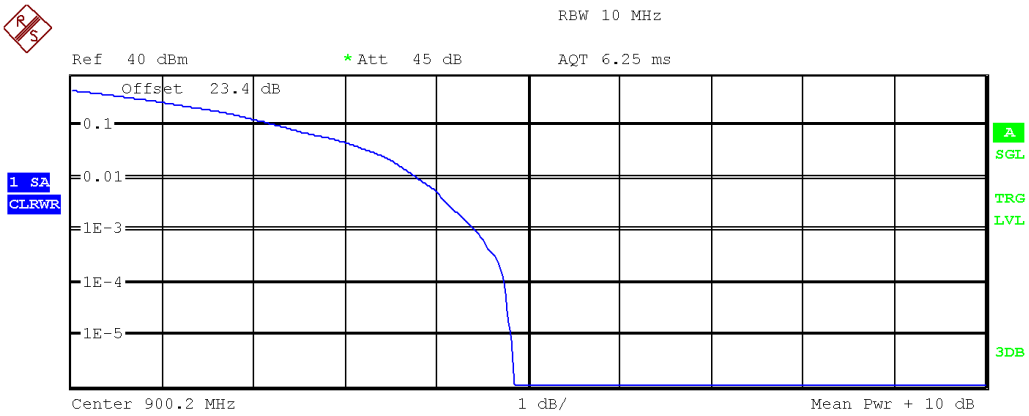
Middle Channel:




**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 11.2MHz**

| | Trace 1 |
|---|---|
| Mean | 20.98 dBm |
| Peak | 26.32 dBm |
| Crest | 5.35 dB |
| 10 % | 2.72 dB |
| 1 % | 4.26 dB |
| .1 % | 5.00 dB |
| .01 % | 5.19 dB |

Highest Channel:




**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 11.2MHz**

| | Trace 1 |
|---|---|
| Mean | 20.66 dBm |
| Peak | 25.50 dBm |
| Crest | 4.84 dB |
| 10 % | 2.32 dB |
| 1 % | 3.80 dB |
| .1 % | 4.42 dB |
| .01 % | 4.74 dB |

# Frequency Stability

## SPECIFICATION

FCC §2.1055.

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

## METHOD

The frequency tolerance measurements over temperature variations were made over the temperature range of –30ºC to +50ºC. The EUT was placed inside a climatic chamber and the temperature was raised hourly in 10ºC steps from –30ºC up to +50ºC.
The supply voltage was varied between 85% and 115% of nominal voltage.

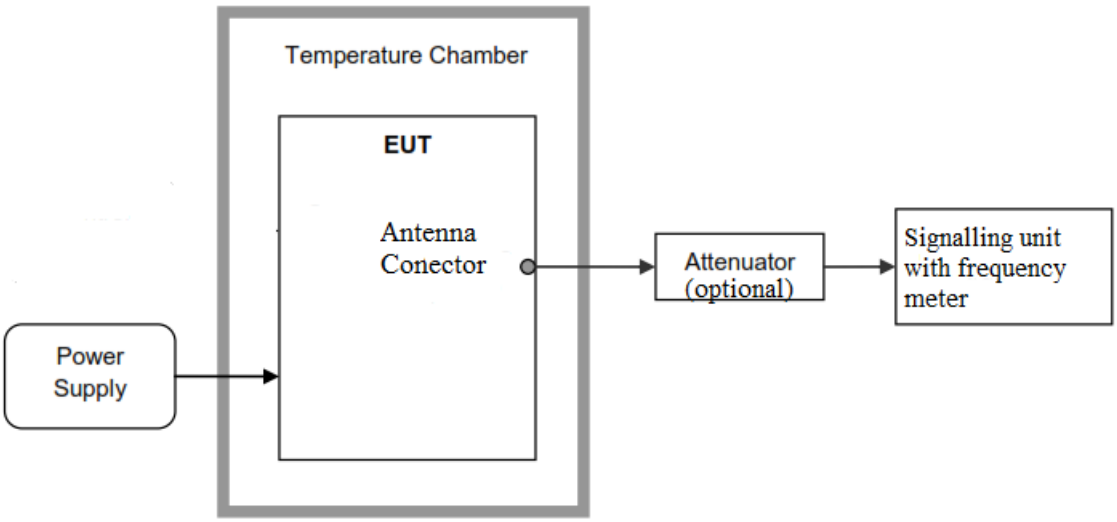
The EUT was set in “Radio Resource Control (RRC) mode” in the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case LTE mode for conducted power was used for the test.

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.

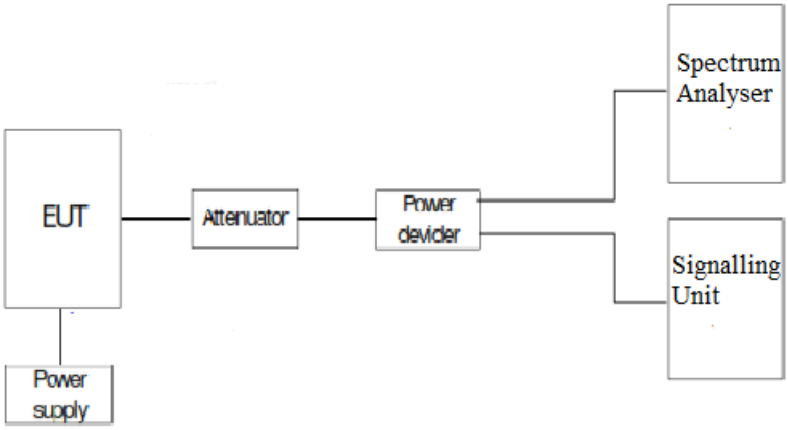
The reference point measurements were made at the RF output terminals of the EUT using an attenuator. power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

## TEST SETUP

Frequency tolerance.



Reference points *f*L and *fH.*




RESULTS

Frequency stability over temperature variations.

LTE Cat. M1 Band 8:

| Temperature (ºC) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|
| +50 | 5000 | 5.558643 |
| +40 | 10000 | 11.11728 |
| +30 | 3350 | 3.724291 |
| +20 | 6700 | 7.448582 |
| +10 | 6700 | 7.448582 |
| 0 | 11650 | 12.9516 |
| -10 | 1650 | 1.834352 |
| -20 | 10000 | 11.11728 |
| -30 | 10000 | 11.11728 |

LTE NB-IoT Band 8:

| Temperature (ºC) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|
| +50 | -4,25 | -0,004724847 |
| +40 | -1,61 | -0,001789883 |
| +30 | -11,37 | -0,012640356 |
| +20 | -3,51 | -0,003902168 |
| +10 | 11,91 | 0,013240689 |
| 0 | 12,61 | 0,014018899 |
| -10 | -6,5 | -0,007226237 |
| -20 | -7,52 | -0,0083602 |
| -30 | -6,23 | -0,00692607 |

Frequency stability over voltage variations.

LTE Cat. M1 Band 8

| Battery Supply voltage | Voltage (V) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|---|
| Vmax | 5.5 | 11650 | 12.9516 |
| Vmin | 3 | 11650 | 12.9516 |

LTE NB-IoT Band 8

| Battery Supply voltage | Voltage (V) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|---|
| Vmax | 5.5 | -7,26 | -0,008071151 |
| Vmin | 3 | -6,15 | -0,006837132 |

Reference points established at the applicable unwanted emissions limit (worst case):

| | LTE Cat. M1 Band 8 |
|---|---|
| *f*L (MHz) | 897.5308 |
| *fH (MHz)* | 900.4879 |

| | LTE NB-IoT Band 8 |
|---|---|
| *f*L (MHz) | 897,5396 |
| *fH (MHz)* | 900,4541 |

Reference points *f*L and *fH* with the worst-case frequency offsets added or subtracted:

| | LTE Cat. M1 Band 8 |
|---|---|
| *f*L (MHz) | 897.519125 |
| *fH (MHz)* | 900.499583 |

| | LTE NB-IoT Band 8 |
|---|---|
| *f*L (MHz) | 897,5397 |
| *fH (MHz)* | 900,4541 |

The reference frequency points stay within the authorized blocks.

Verdict: Pass

# Modulation Characteristics

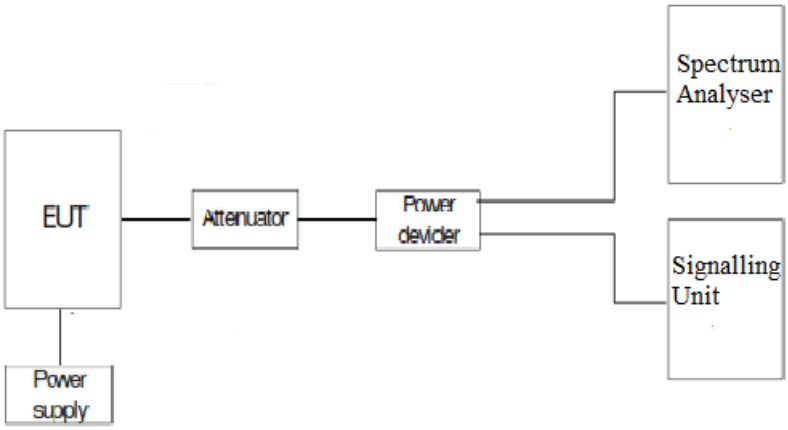
## SPECIFICATION

FCC §2.1047

## 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).

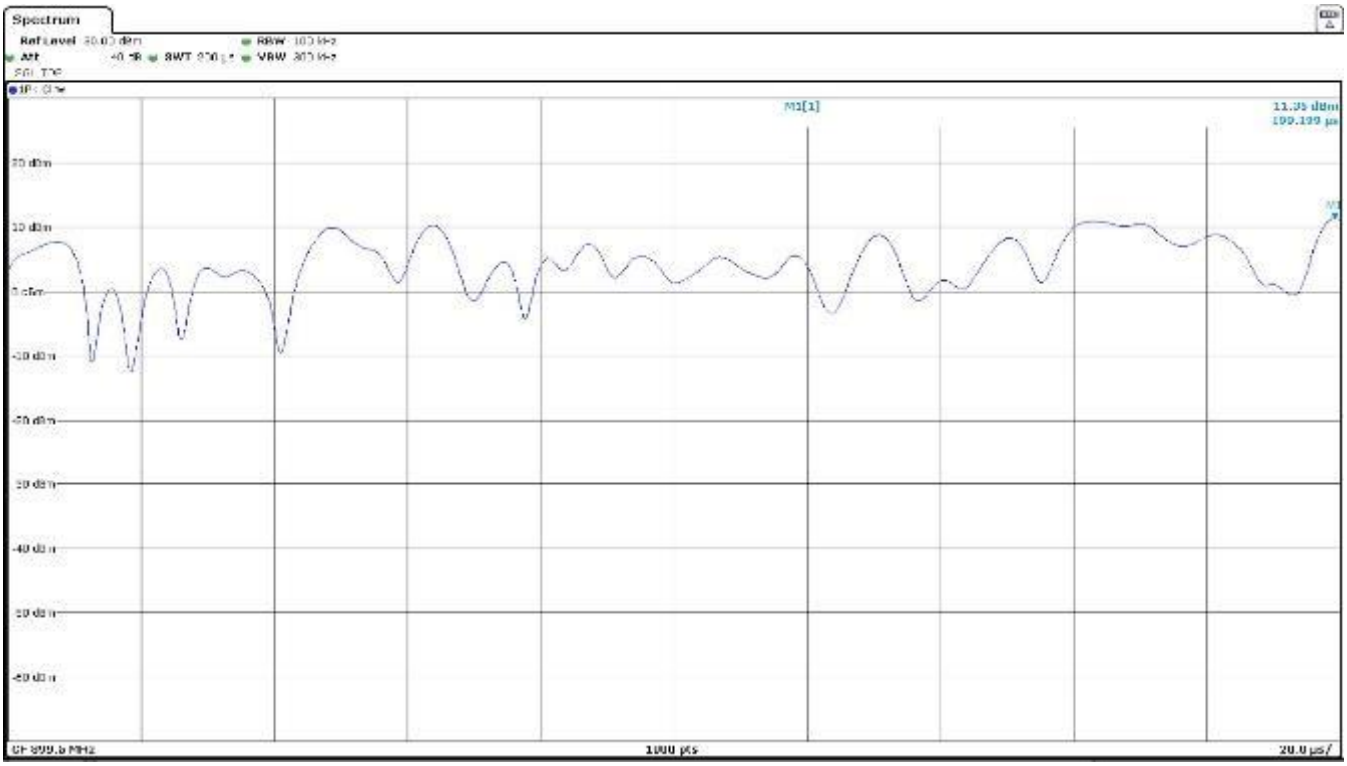
## TEST SETUP



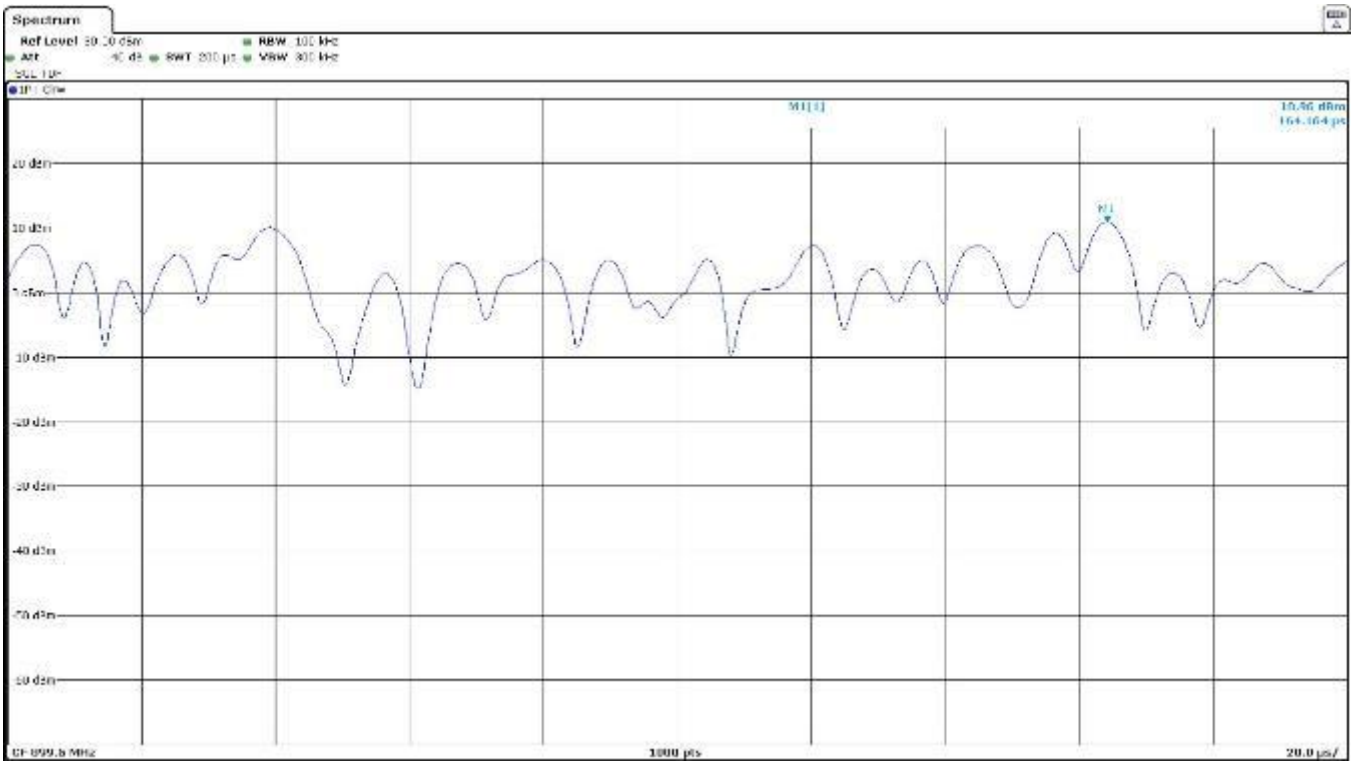

## RESULTS

The following plot shows the modulation schemes in the EUT.

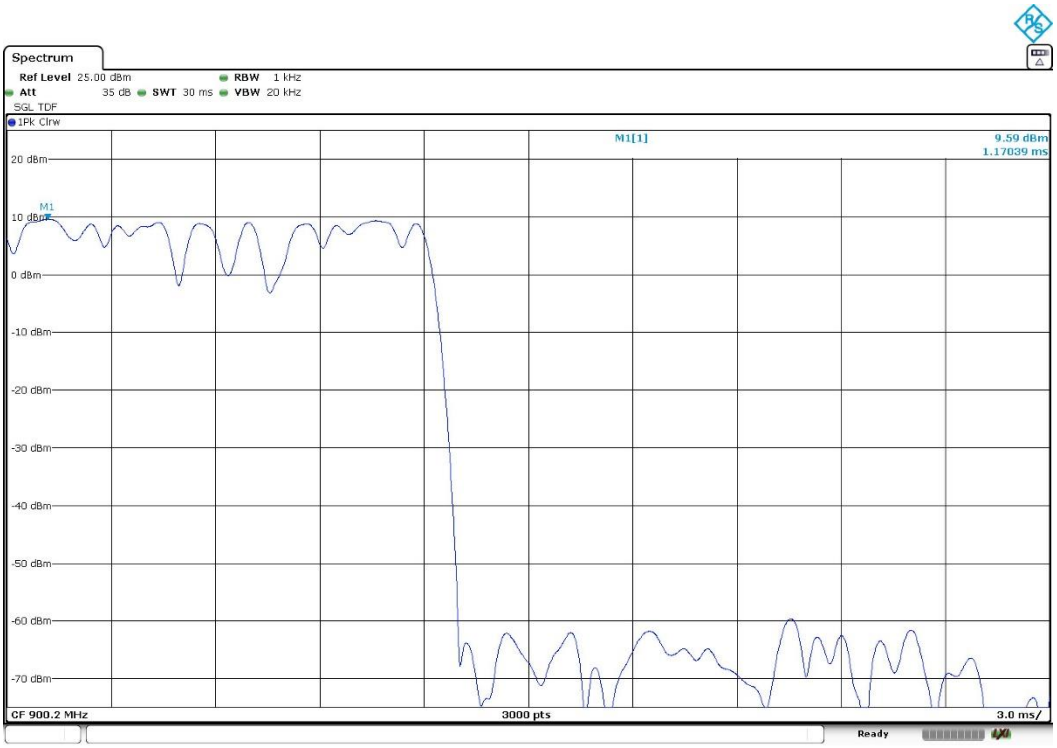
LTE Cat. M1 Band 8 modulation. QPSK.



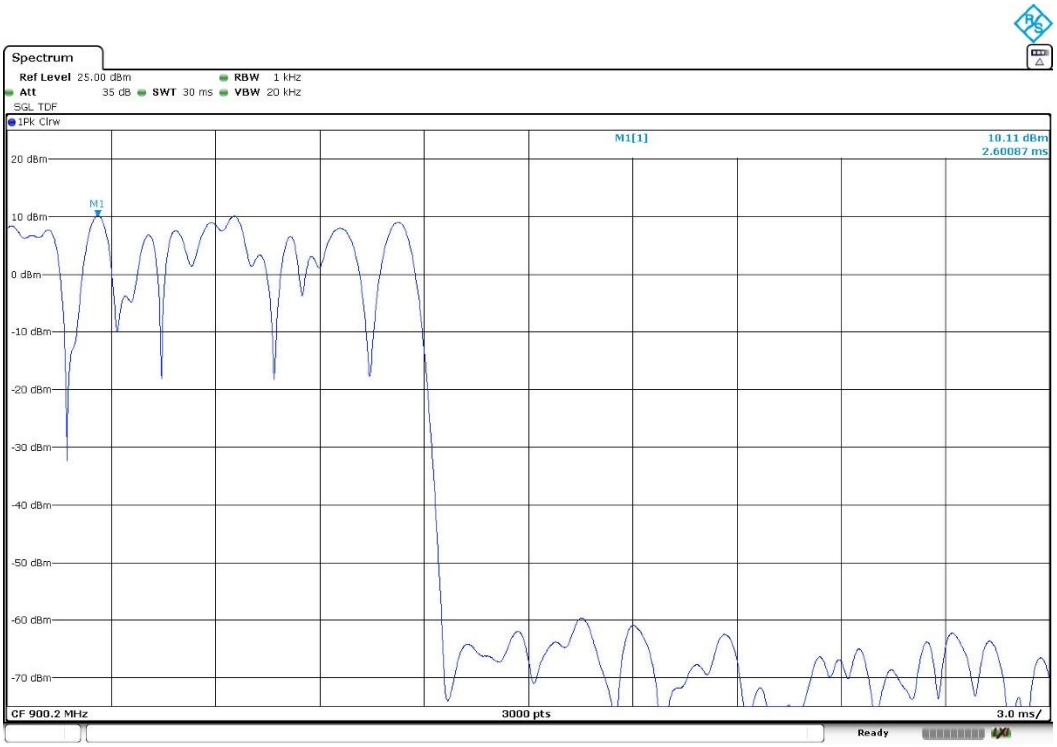

LTE Cat. M1 Band 8 modulation. 16QAM.



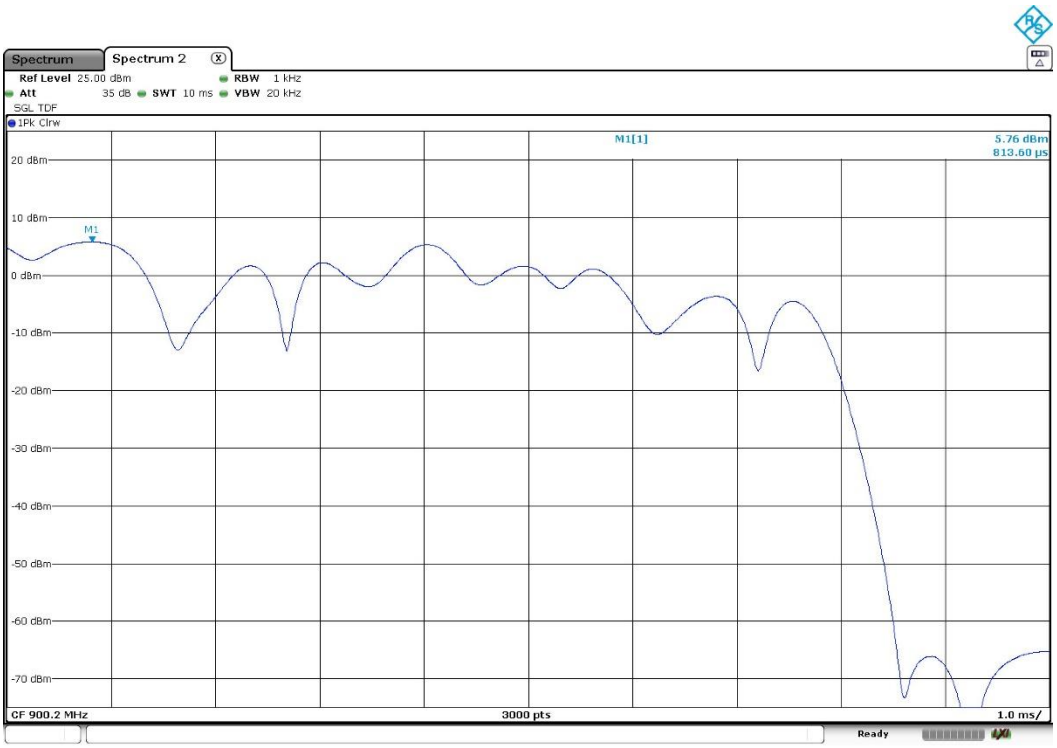
LTE NB-IoT Band 8 modulation. Pi/4-QPSK. 1 tone of 3.75kHz



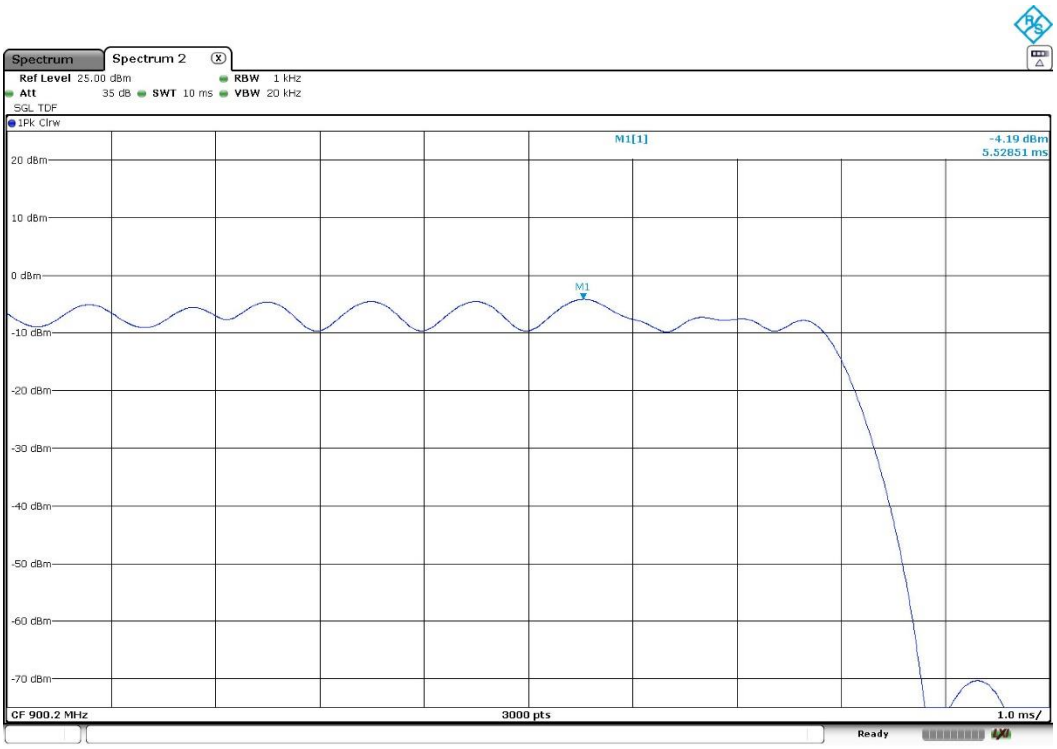

LTE NB-IoT Band 8 modulation. Pi/2-BPSK. 1 tone of 3.75kHz



LTE NB-IoT Band 8 modulation. Pi/2-BPSK. 1 tone 15kHz




LTE NB-IoT Band 8 modulation. Pi/2-BPSK. 12 tones 15kHz



# Occupied Bandwidth

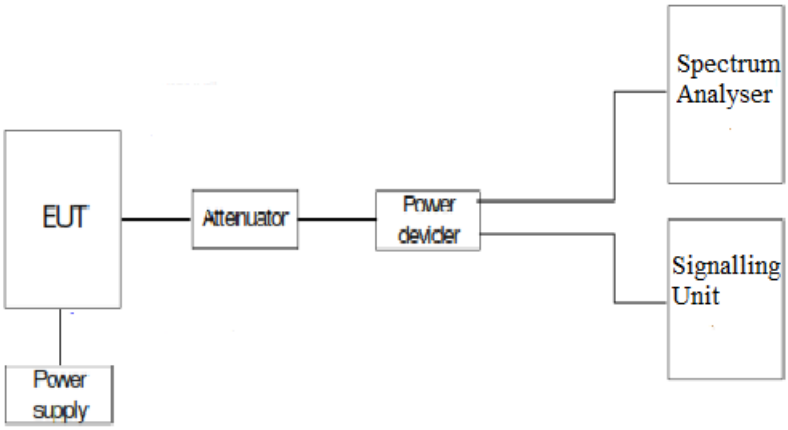
## SPECIFICATION

§2.1049

## 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 (see next plots)

The worst case of occupied bandwidth corresponds to all Resource Blocks (RB) offset 0 regardless either the Narrow band position or the nominal bandwidth selected.

LTE Cat. M1 QPSK MODULATION. BW = 1.4 MHz (Band 8). Narrow band: 0.

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (MHz) | 1.111 | 1.113 | 1.109 |
| -26 dBc bandwidth (MHz) | 1.376 | 1.423 | 1.428 |
| Measurement uncertainty (kHz) | <±5.20 | | |

LTE Cat. M1 16QAM MODULATION. BW = 1.4 MHz (Band 8). Narrow band: 0.

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (MHz) | 0.938 | 0.952 | 0.944 |
| -26 dBc bandwidth (MHz) | 1.304 | 1.316 | 1.291 |
| Measurement uncertainty (kHz) | <±5.20 | | |

LTE NB-IoT pi/4-QPSK MODULATION (Band 8). 1 tone of 3.75kHz, Offset= 0

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (KHz) | 61,933 | 61,133 | 61,400 |
| -26 dBc bandwidth (KHz) | 41,882 | 41,701 | 41,739 |
| Measurement uncertainty (kHz) | <±5.20 | | |

LTE NB-IoT pi/2-BPSK MODULATION (Band 8). 1 tone of 3.75kHz, Offset= 0

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (KHz) | 57,067 | 57,067 | 56,333 |
| -26 dBc bandwidth (KHz) | 41,215 | 40,834 | 41,139 |
| Measurement uncertainty (kHz) | <±5.20 | | |

LTE NB-IoT pi/4-QPSK MODULATION (Band 8). 12 tones of 15kHz, Offset= 0

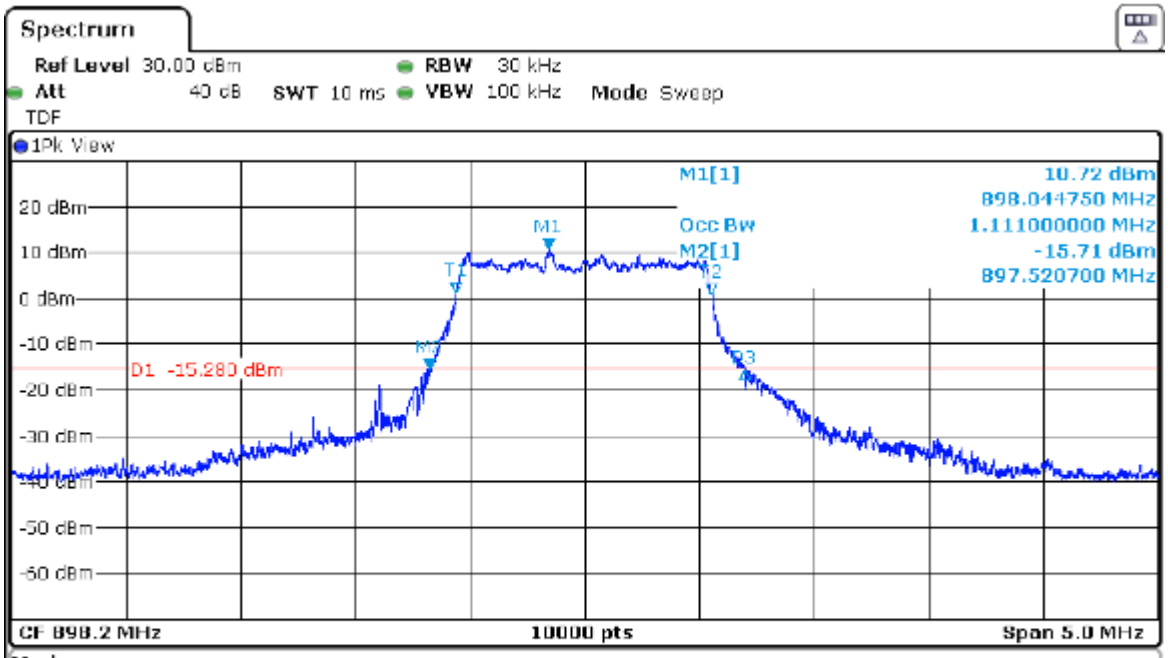
| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (KHz) | 186,533 | 186,533 | 186,533 |
| -26 dBc bandwidth (KHz) | 288,450 | 289,230 | 288,450 |
| Measurement uncertainty (kHz) | <±5.20 | | |

LTE NB-IoT pi/2-BPSK MODULATION (Band 8). 1 tone of 15kHz, Offset= 11

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (KHz) | 128,13333 | 127,33333 | 127,20000 |
| -26 dBc bandwidth (KHz) | 127,68000 | 127,10000 | 126,83000 |
| Measurement uncertainty (kHz) | <±5.20 | | |

LTE Cat. M1 QPSK MODULATION. BW = 1.4 MHz (Band 8)

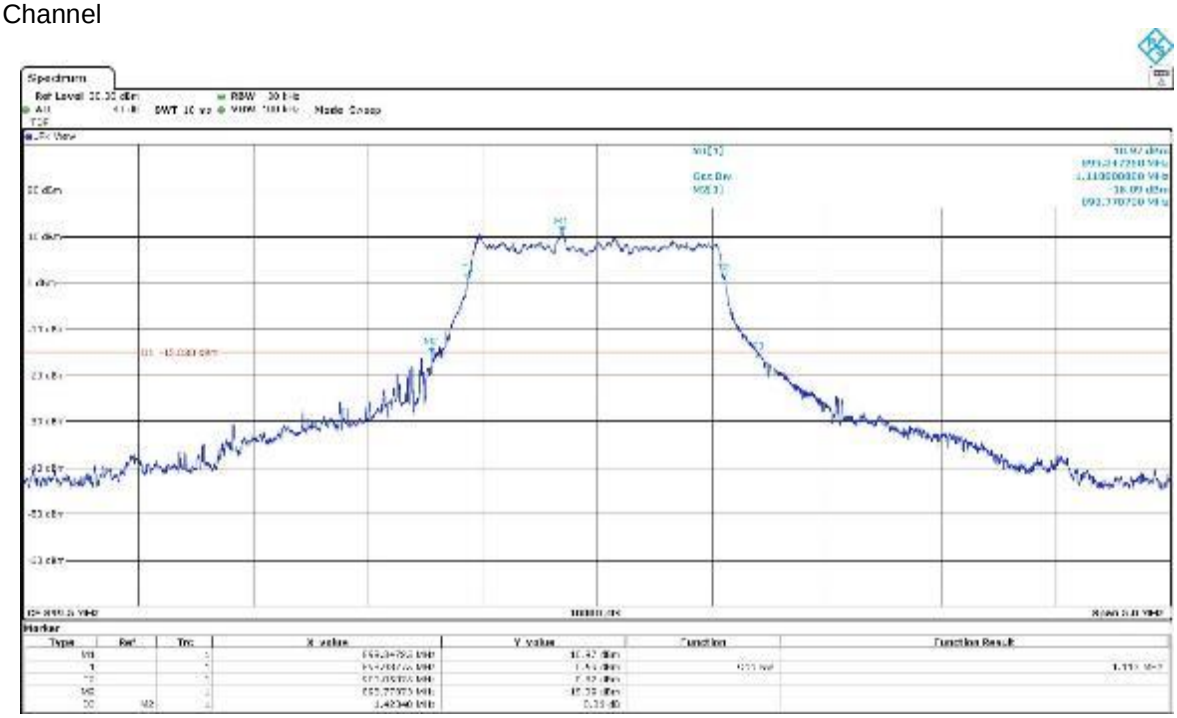
Lowest Channel



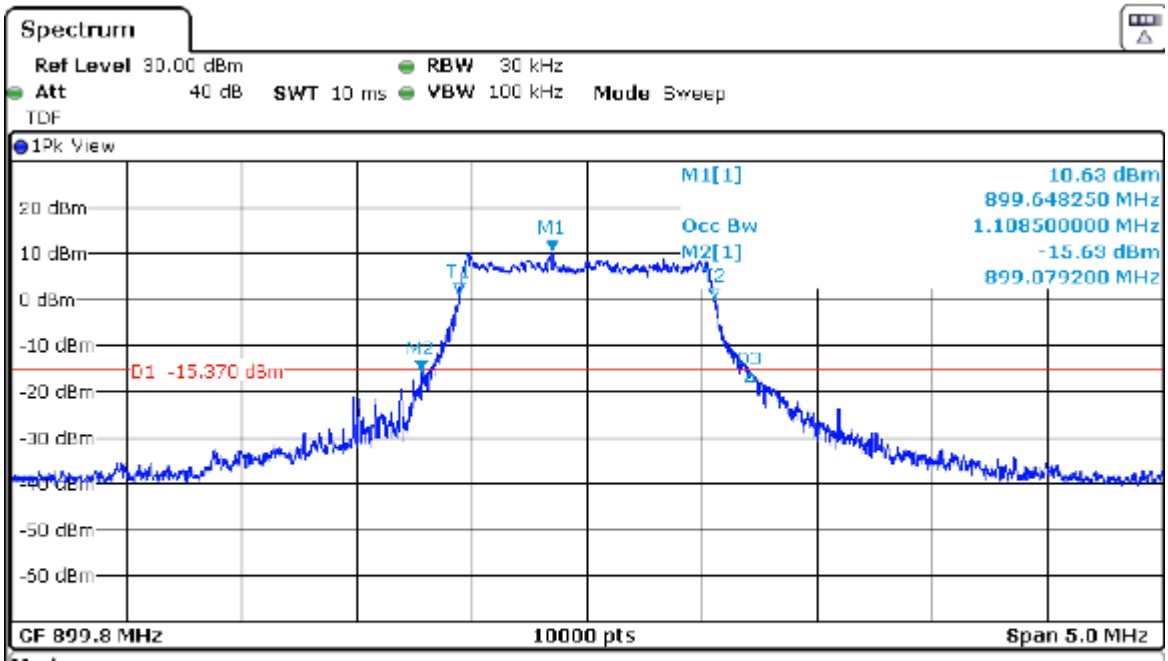

Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 898.04475 MHz | 10.72 dBm | | |
| T1 | | 1 | 897.63875 MHz | 1.22 dBm | Occ Bw | 1.111 MHz |
| T2 | | 1 | 898.74975 MHz | 0.85 dBm | | |
| M2 | | 1 | 897.5207 MHz | -15.71 dBm | | |
| D3 | M2 | 1 | 1.37613 MHz | 0.13 dB | | |

Middle Channel



Highest Channel

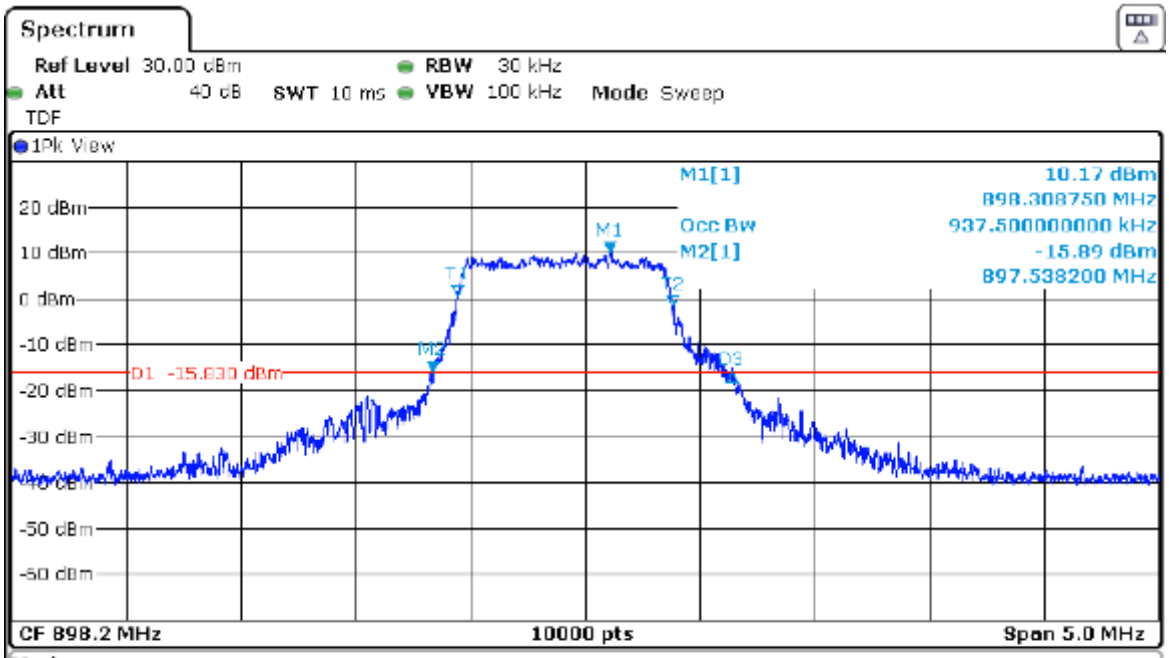



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 899.64825 MHz | 10.63 dBm | | |
| T1 | | 1 | 899.24175 MHz | 1.10 dBm | Occ Bw | 1.1085 MHz |
| T2 | | 1 | 900.35025 MHz | 0.12 dBm | | |
| M2 | | 1 | 899.0792 MHz | -15.63 dBm | | |
| D3 | M2 | 1 | 1.42813 MHz | 0.10 dB | | |

LTE Cat. M1 16QAM MODULATION. BW = 1.4 MHz (Band 8)

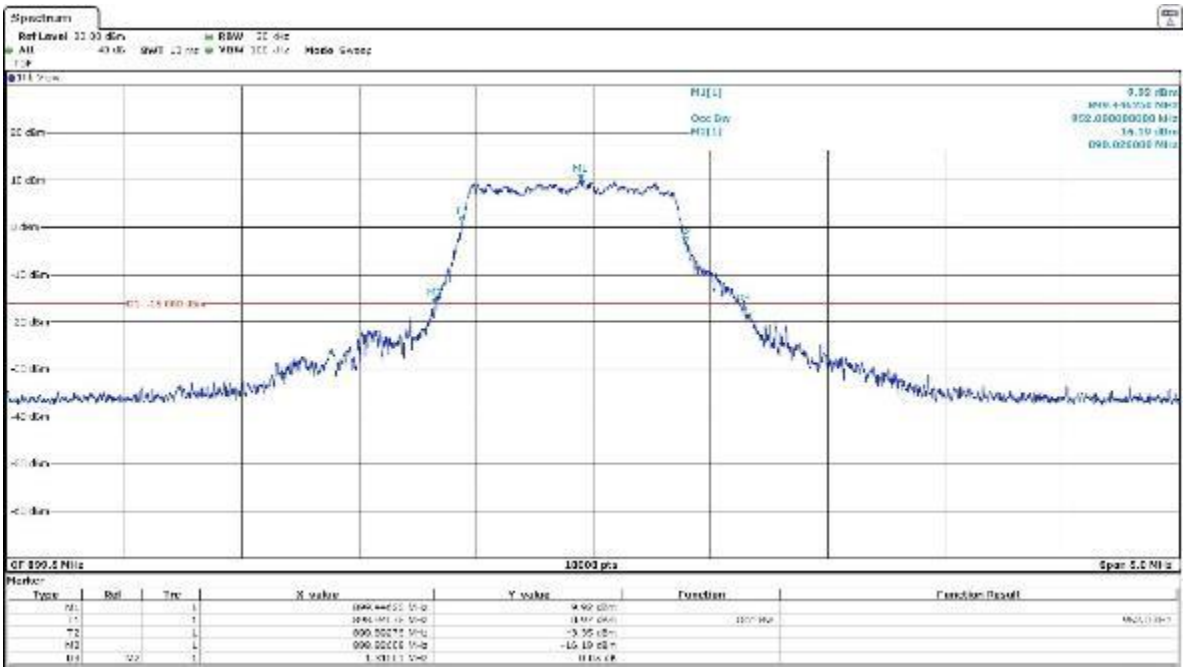
Lowest Channel



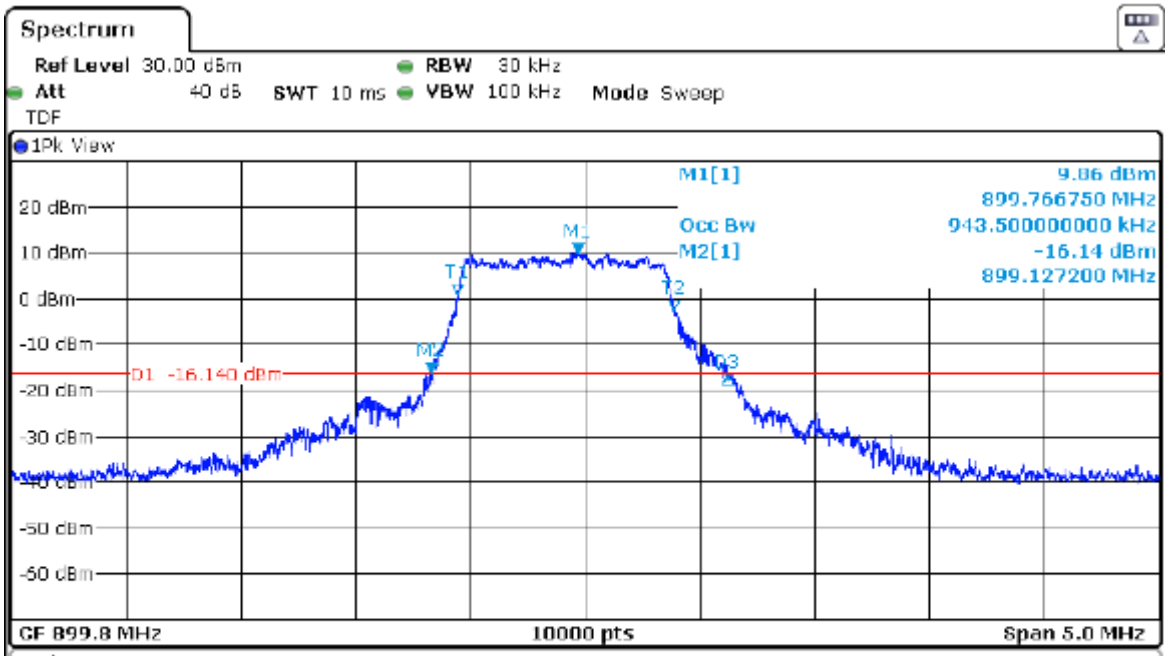

Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 898.30875 MHz | 10.17 dBm | | |
| T1 | | 1 | 897.64525 MHz | 0.70 dBm | Occ Bw | 937.5 kHz |
| T2 | | 1 | 898.58275 MHz | -1.54 dBm | | |
| M2 | | 1 | 897.5382 MHz | -15.89 dBm | | |
| D3 | M2 | 1 | 1.30413 MHz | -0.07 dB | | |

Middle Channel



Highest Channel

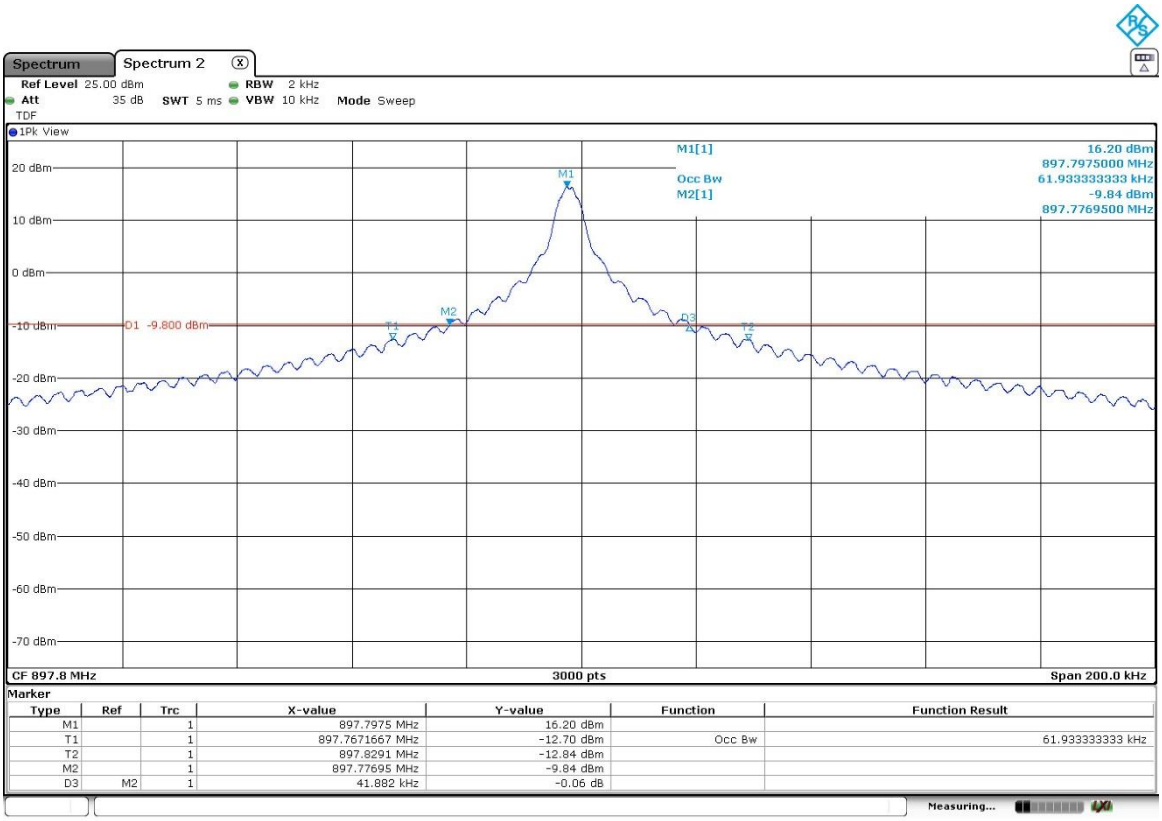



Marker

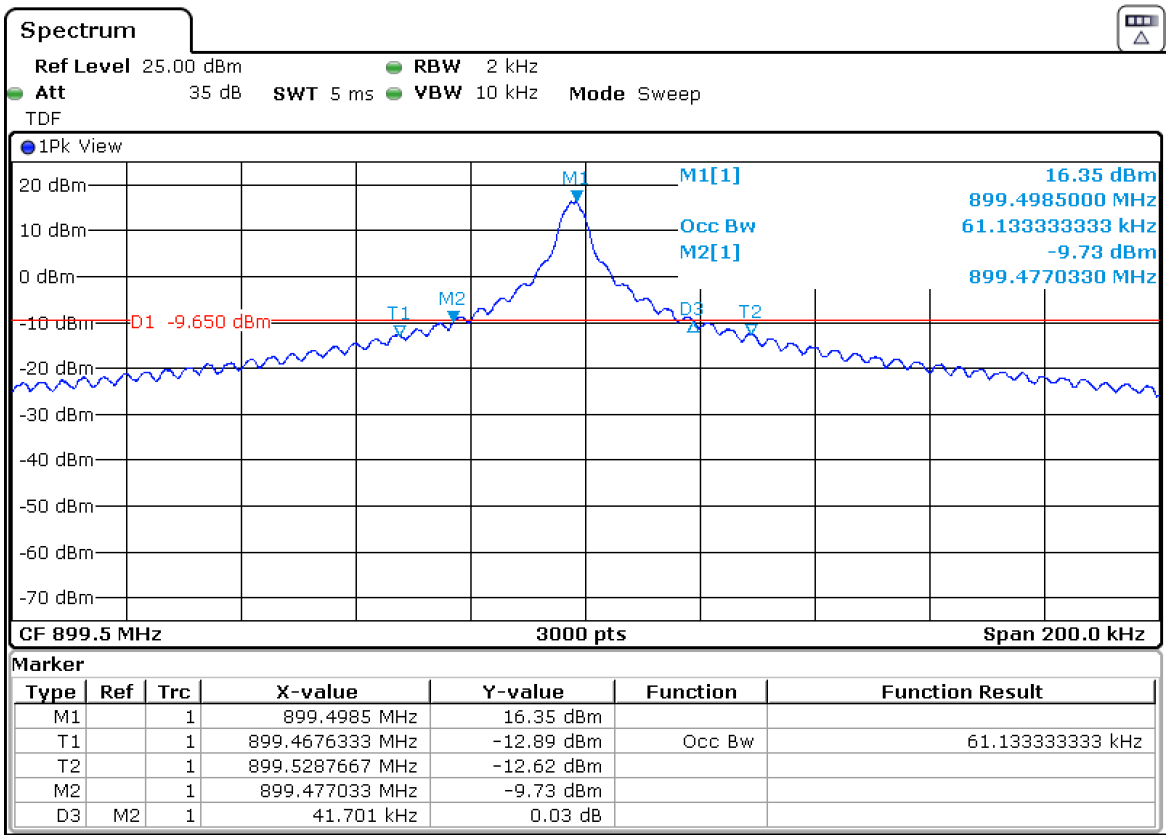
| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 899.76675 MHz | 9.86 dBm | | |
| T1 | | 1 | 899.24425 MHz | 0.81 dBm | Occ Bw | 943.5 kHz |
| T2 | | 1 | 900.18775 MHz | -2.52 dBm | | |
| M2 | | 1 | 899.1272 MHz | -16.14 dBm | | |
| D3 | M2 | 1 | 1.29063 MHz | -0.28 dB | | |

LTE NB-IoT pi/4-QPSK MODULATION (Band 8). 1 tone of 3.75kHz, Offset= 0

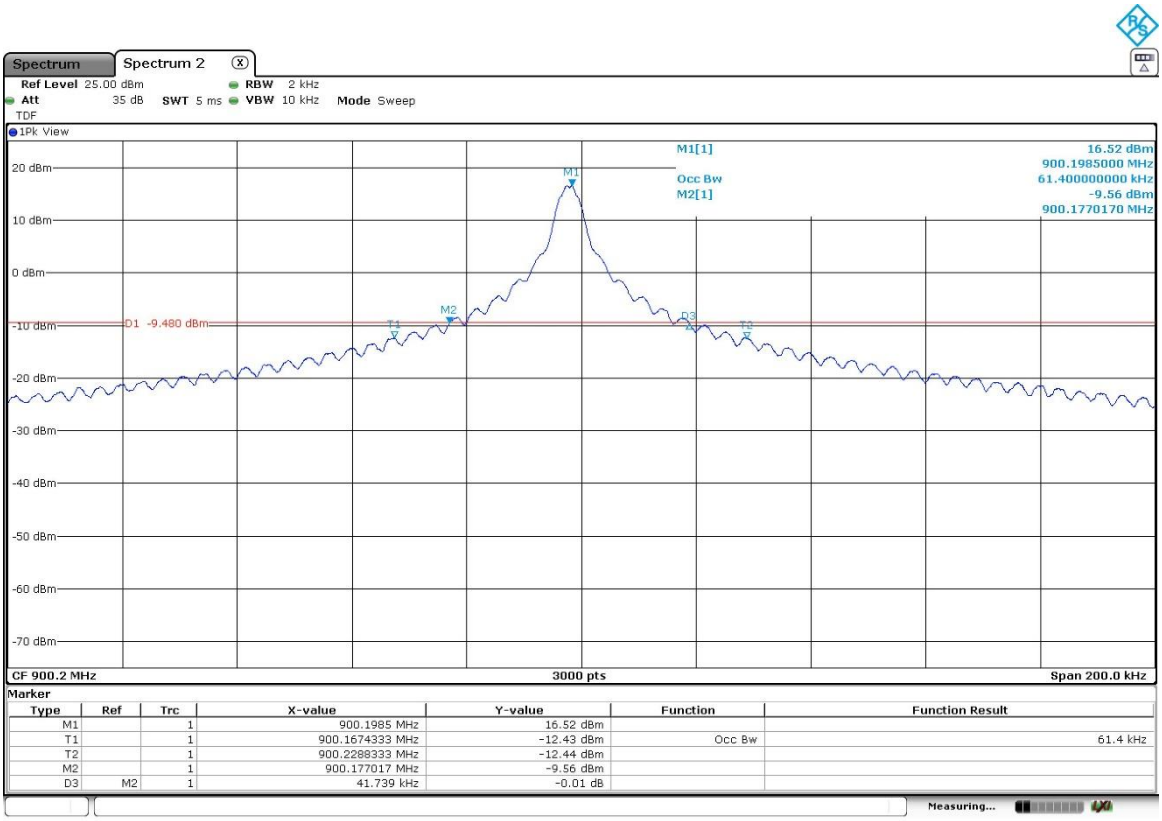
Lowest Channel




Middle Channel



## Highest Channel

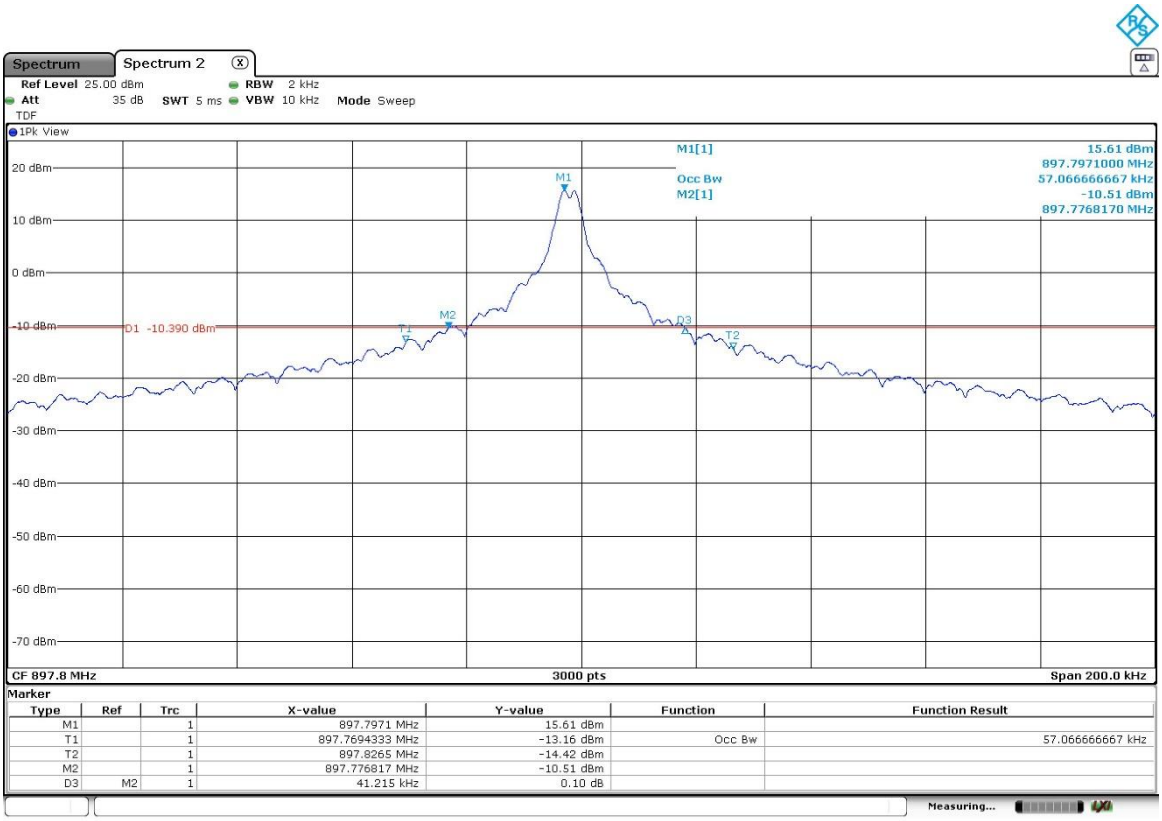



Marker

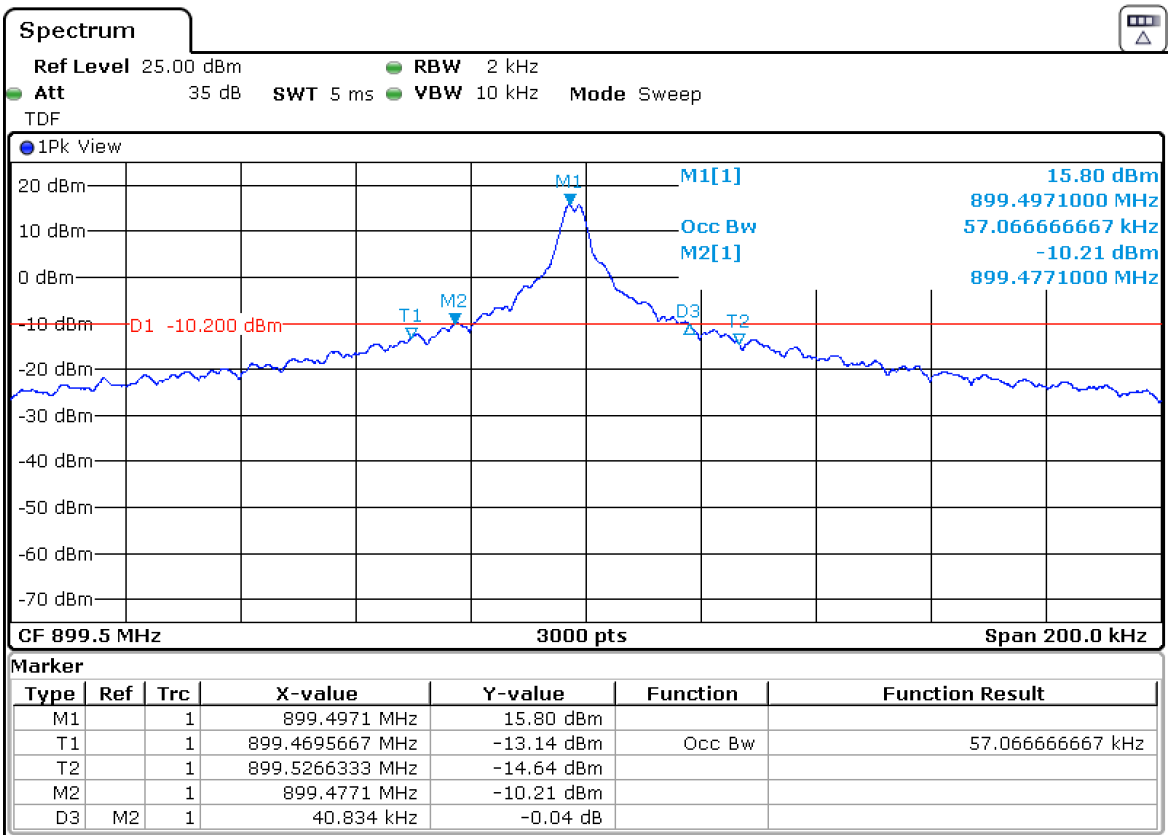
| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 900.1985 MHz | 16.52 dBm | | |
| T1 | | 1 | 900.1674333 MHz | -12.43 dBm | Occ Bw | 61.4 kHz |
| T2 | | 1 | 900.2288333 MHz | -12.44 dBm | | |
| M2 | | 1 | 900.177017 MHz | -9.56 dBm | | |
| D3 | M2 | 1 | 41.739 kHz | -0.01 dB | | |

LTE NB-IoT pi/2-BPSK MODULATION (Band 8). 1 tone of 3.75kHz, Offset= 0

Lowest Channel

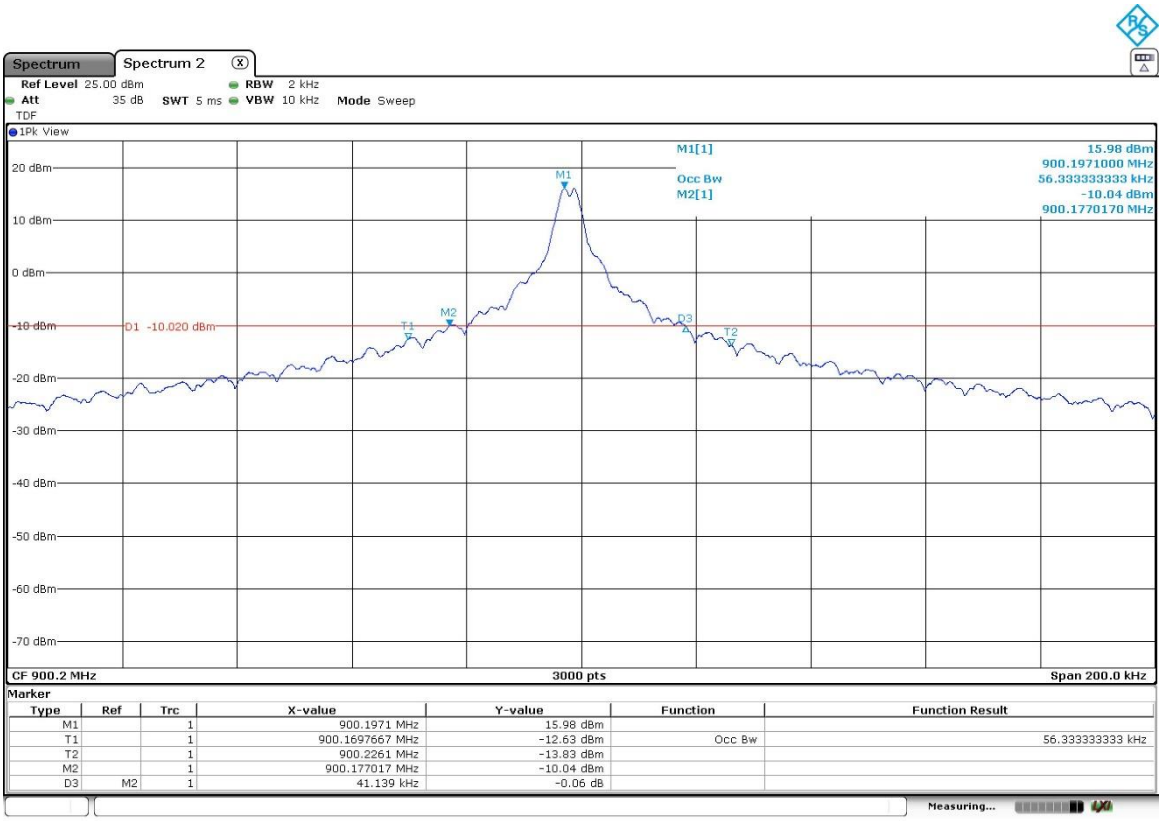



Middle Channel



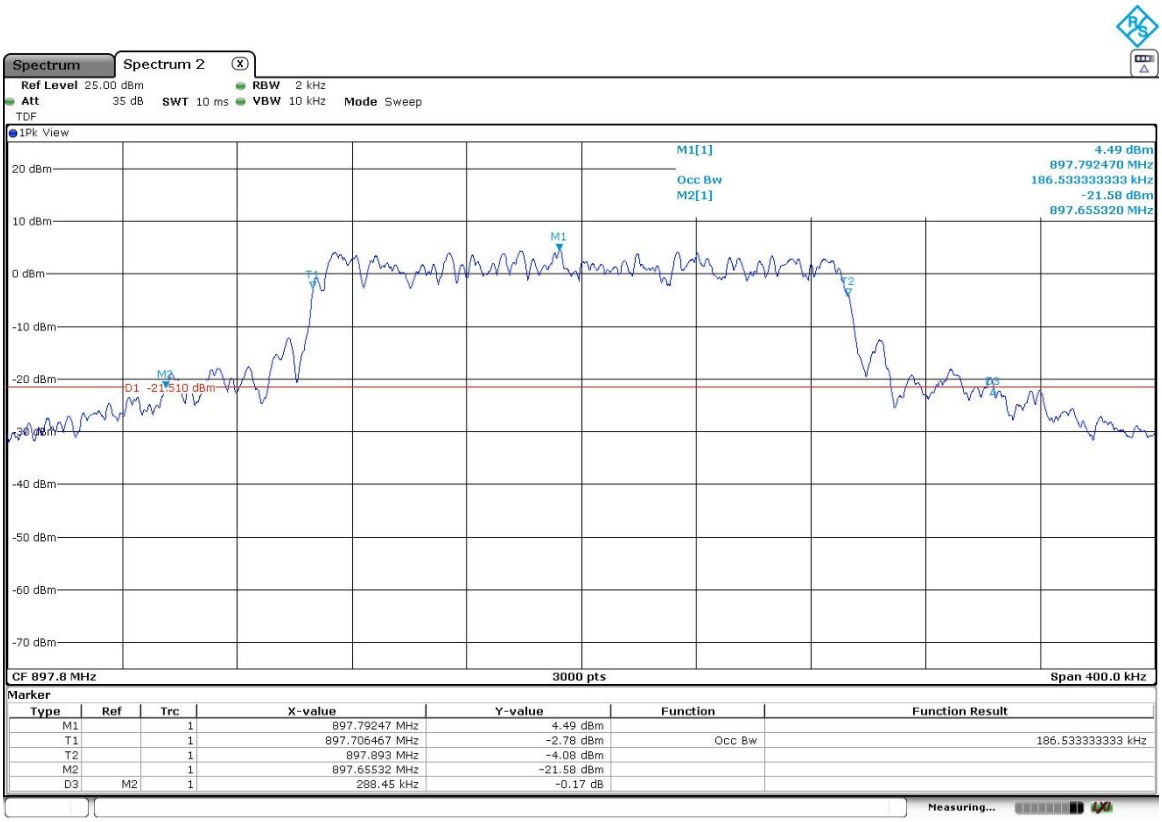

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 899.4971 MHz | 15.80 dBm | | |
| T1 | | 1 | 899.4695667 MHz | -13.14 dBm | Occ Bw | 57.066666667 kHz |
| T2 | | 1 | 899.5266333 MHz | -14.64 dBm | | |
| M2 | | 1 | 899.4771 MHz | -10.21 dBm | | |
| D3 | M2 | 1 | 40.834 kHz | -0.04 dB | | |

## Highest Channel

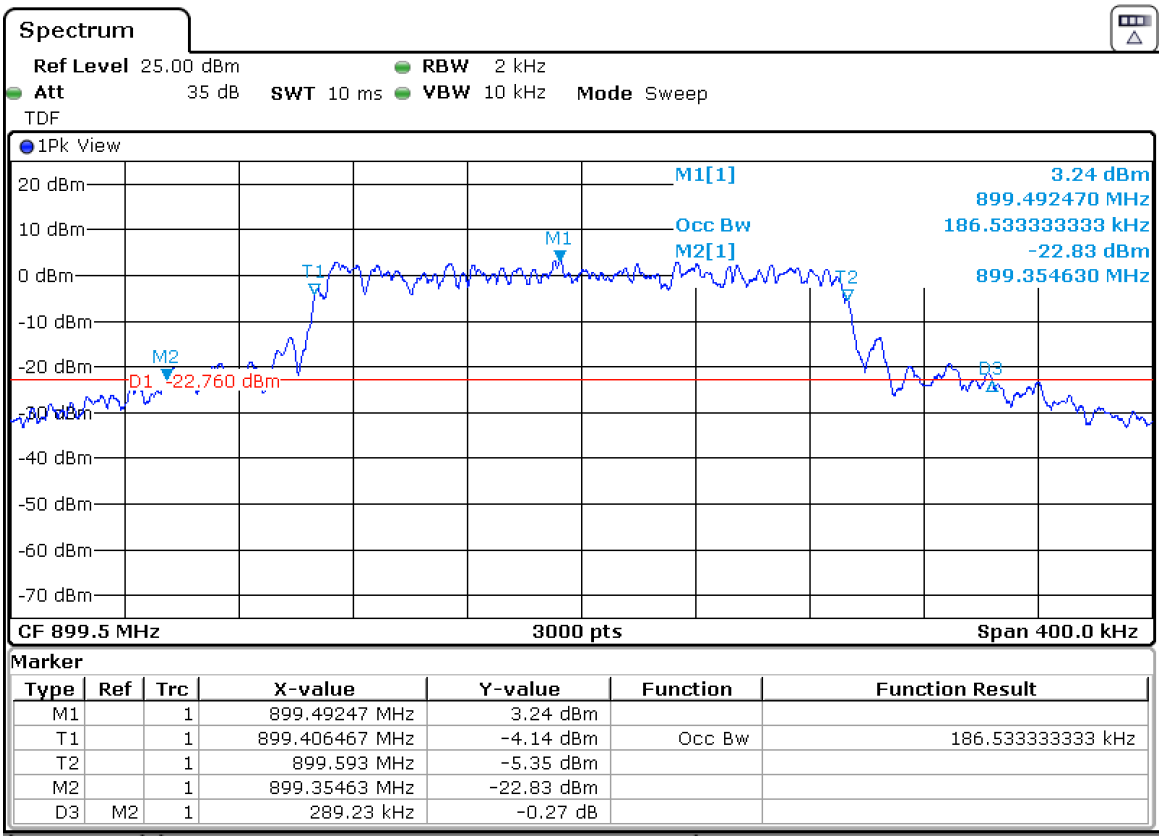


LTE NB-IoT pi/4-QPSK MODULATION (Band 8). 12 tones of 15kHz, Offset= 0

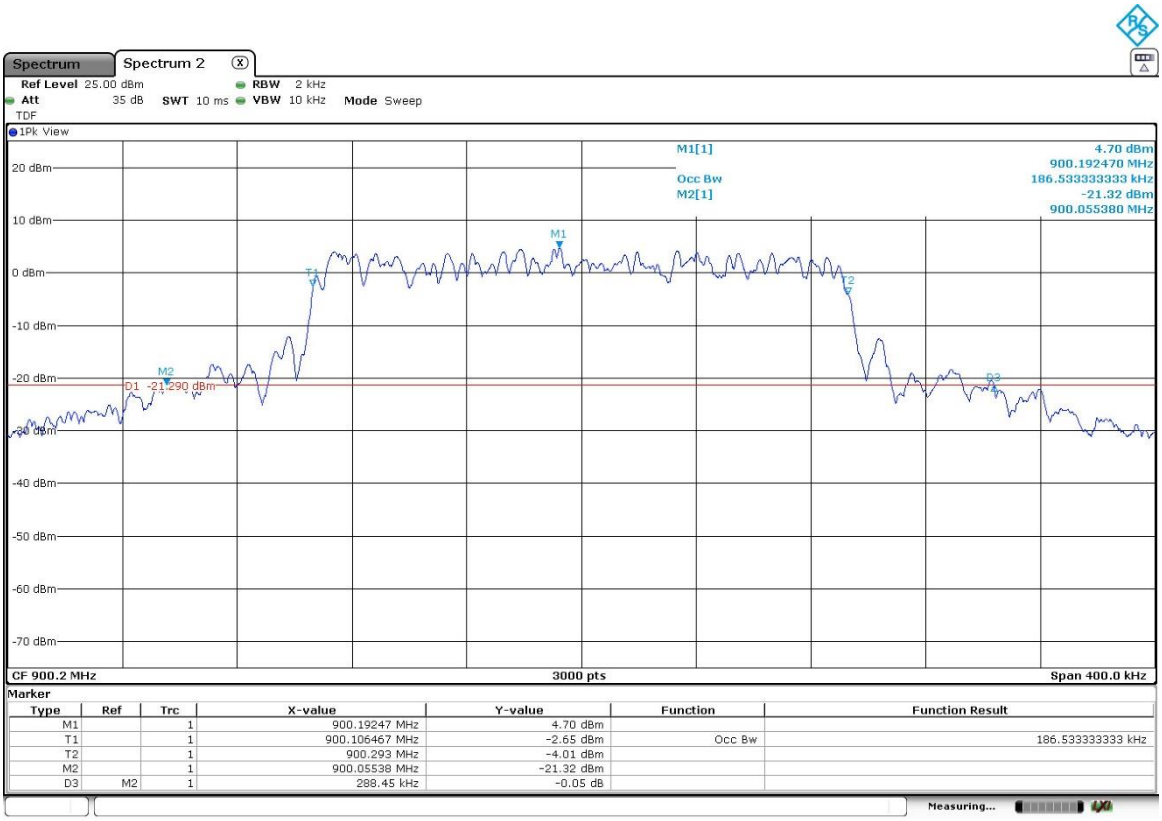
Lowest Channel




Middle Channel

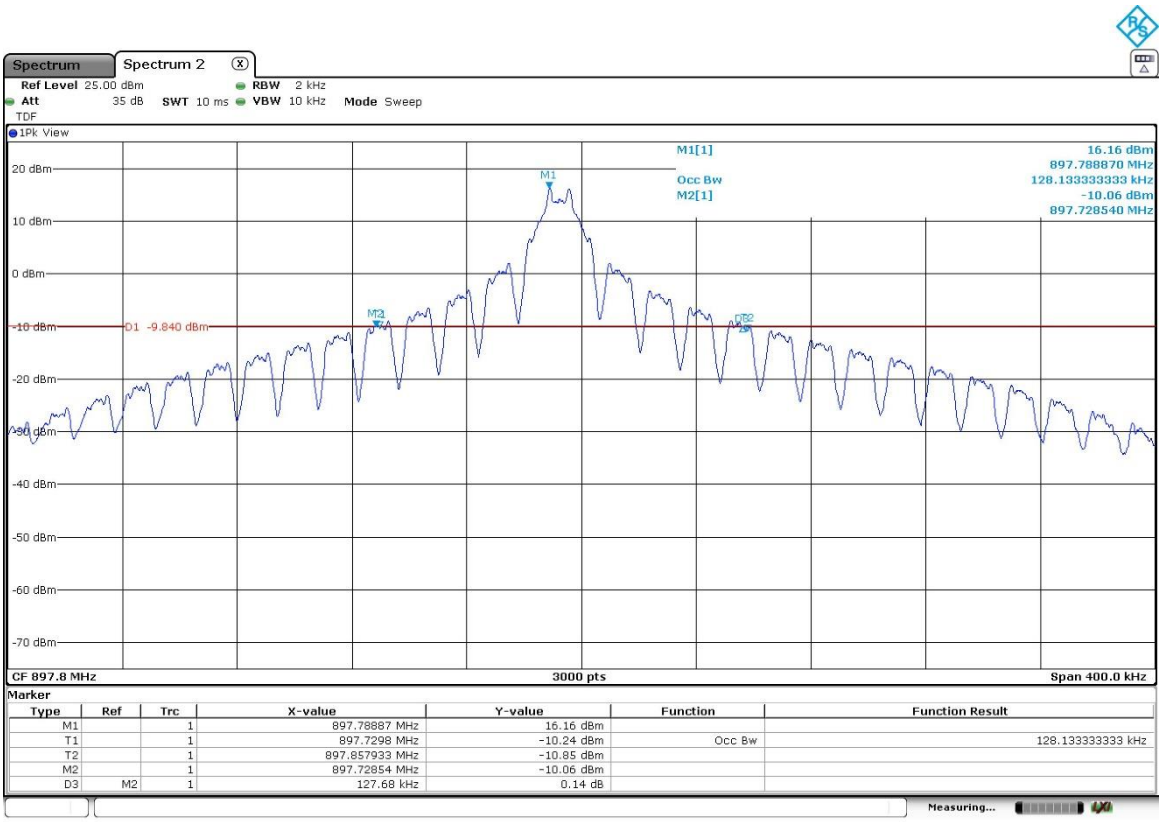


## Highest Channel

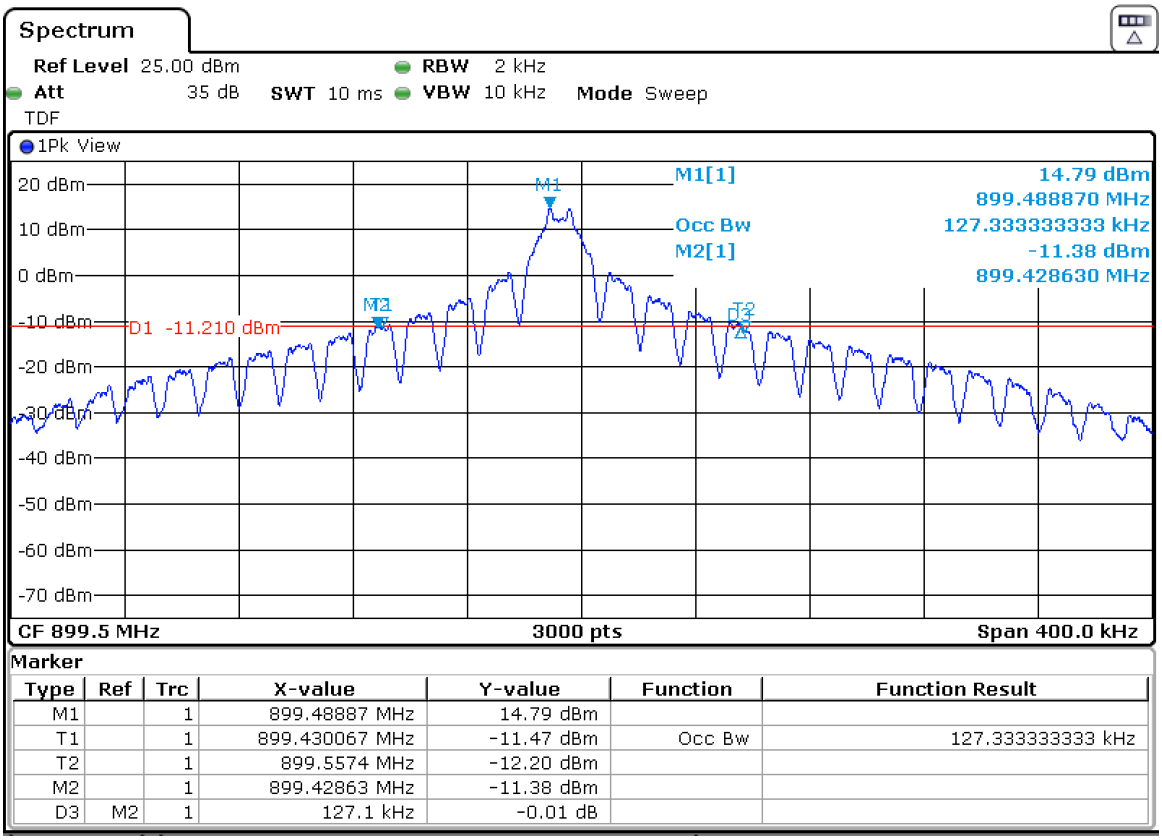


LTE NB-IoT pi/2-BPSK MODULATION (Band 8). 1 tone of 15kHz, Offset= 11

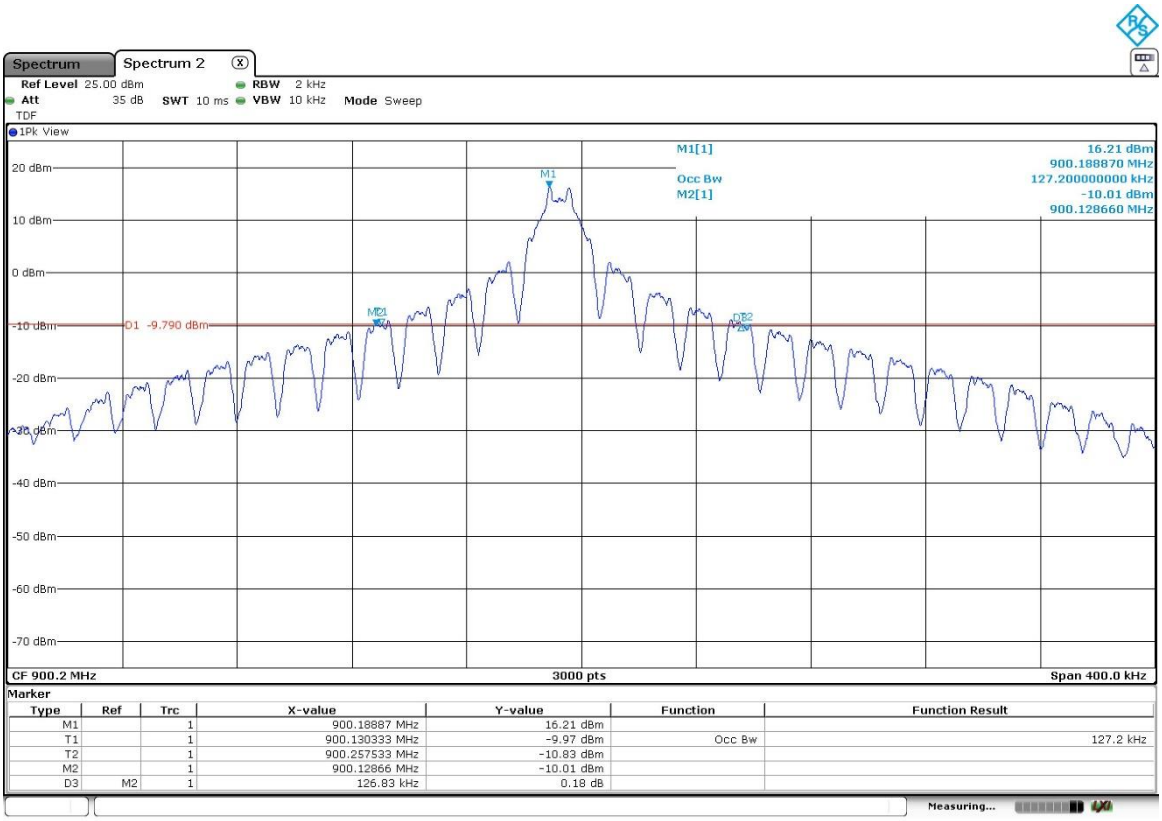
Lowest Channel




Middle Channel



## Highest Channel



# Spurious emissions at antenna terminals

## SPECIFICATION

**LTE Cat M1 Band 8. LTE NB-IoT Band 8**. FCC Subpart P §27.1509 (a):

FCC §27.1509 (a):

> (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:
>
> For 900 MHz broadband operations in 897.5-900.5 MHz band by at least 43 + 10 log (P) dB.

## METHOD

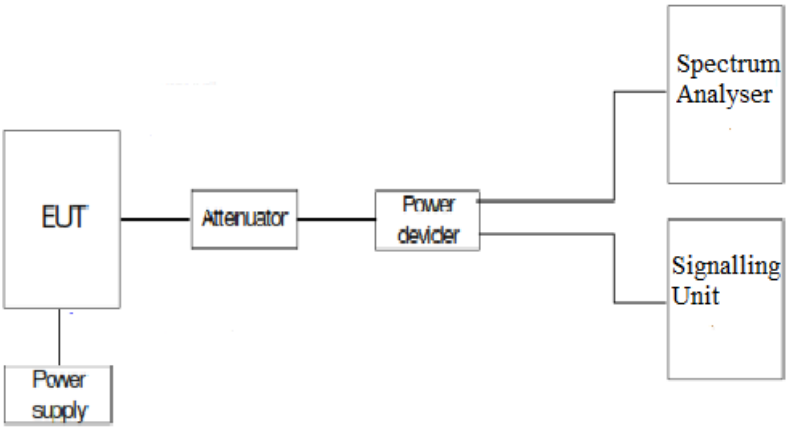
The EUT RF output connector was connected to a spectrum analyser and to the Universal Radio Communication tester R&S CMW500 (selecting maximum transmission power of the EUT and different modes of modulation) using a 50 ohm attenuator and a power divider.

The spectrum was investigated from 9 kHz to 10 GHz for LTE Band 8.

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 (see plots in next pages)

LTE Cat. M1 Band 8

1. CHANNEL: LOWEST
No spurious signals were found at less than 20dB respect to the limit in all the range.

2. CHANNEL: MIDDLE
No spurious signals were found at less than 20dB respect to the limit in all the range.

3. CHANNEL: HIGHEST
No spurious signals were found at less than 20dB respect to the limit in all the range.

LTE NB-IoT Band 8. 1 tone of 3.75kHz

1. CHANNEL: LOWEST
No spurious signals were found at less than 20dB respect to the limit in all the range.

2. CHANNEL: MIDDLE

No spurious signals were found at less than 20dB respect to the limit in all the range.

3. CHANNEL: HIGHEST
No spurious signals were found at less than 20dB respect to the limit in all the range.

LTE NB-IoT Band 8. 1 tone of 15kHz

1. CHANNEL: LOWEST
No spurious signals were found at less than 20dB respect to the limit in all the range.

2. CHANNEL: MIDDLE

No spurious signals were found at less than 20dB respect to the limit in all the range.

3. CHANNEL: HIGHEST
No spurious signals were found at less than 20dB respect to the limit in all the range.

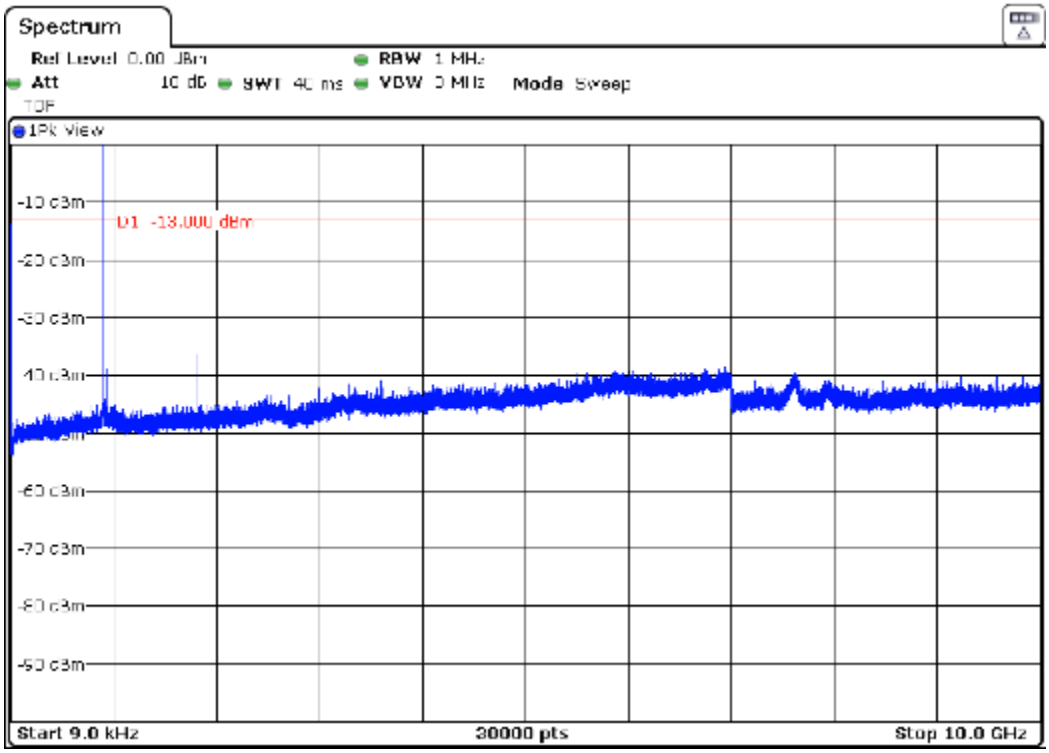
Measurement uncertainty = <±2.76 dB.

Verdict: PASS

LTE Cat. M1 Band 8

1. CHANNEL: LOWEST

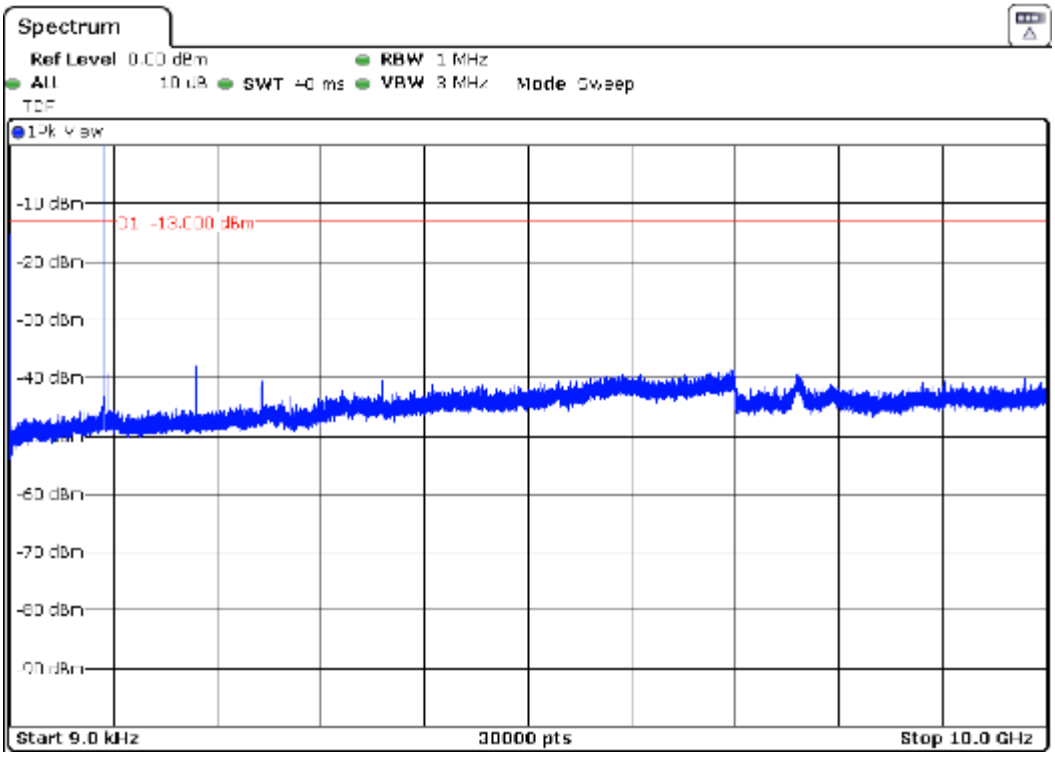
Frequency Range 9 kHz – 10 GHz




Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE

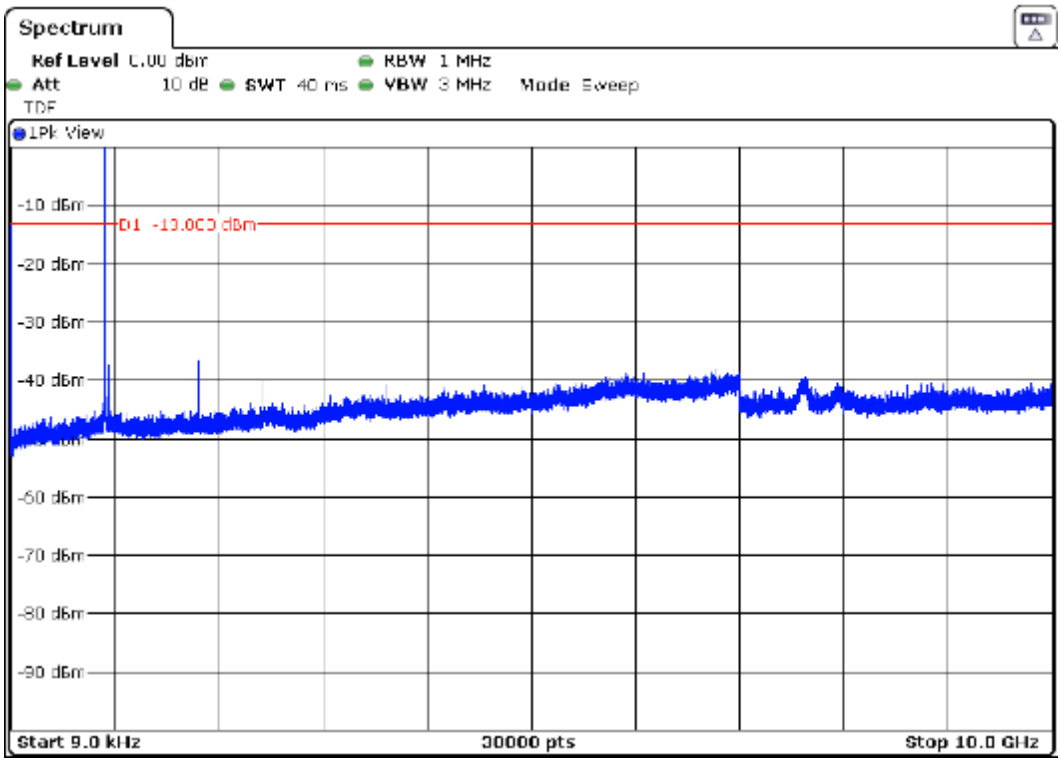
Frequency Range 9 kHz – 10 GHz




Note: The peak above the limit is the carrier frequency.

3. CHANNEL: HIGHEST

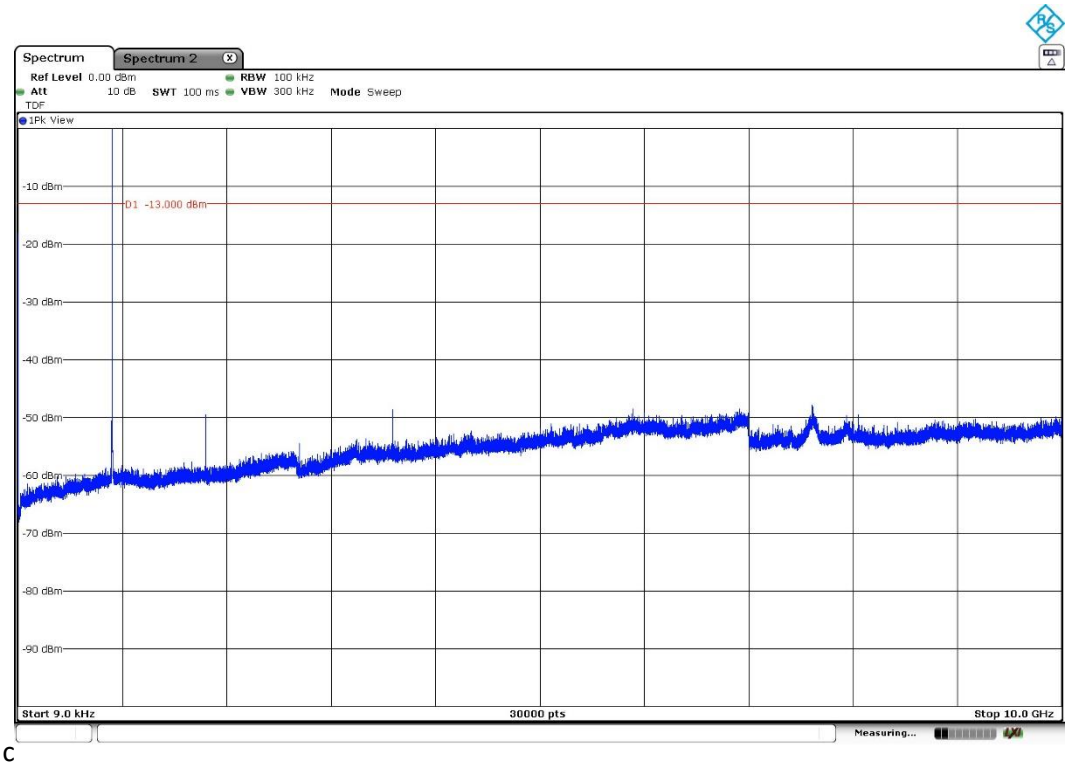
Frequency Range 9 kHz – 10 GHz




Note: The peak above the limit is the carrier frequency.

LTE NB-IoT Band 8. PI/2 – BPSK. 1 tone of 3.75kHz

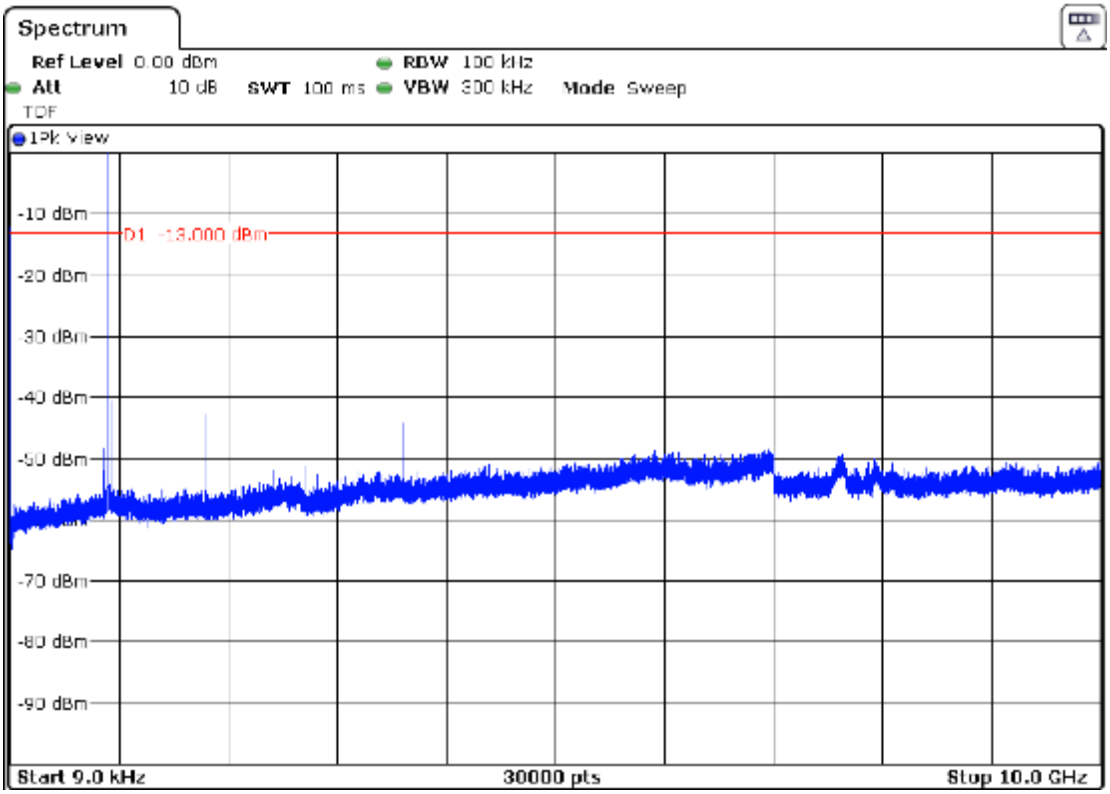
1. CHANNEL: LOWEST




C

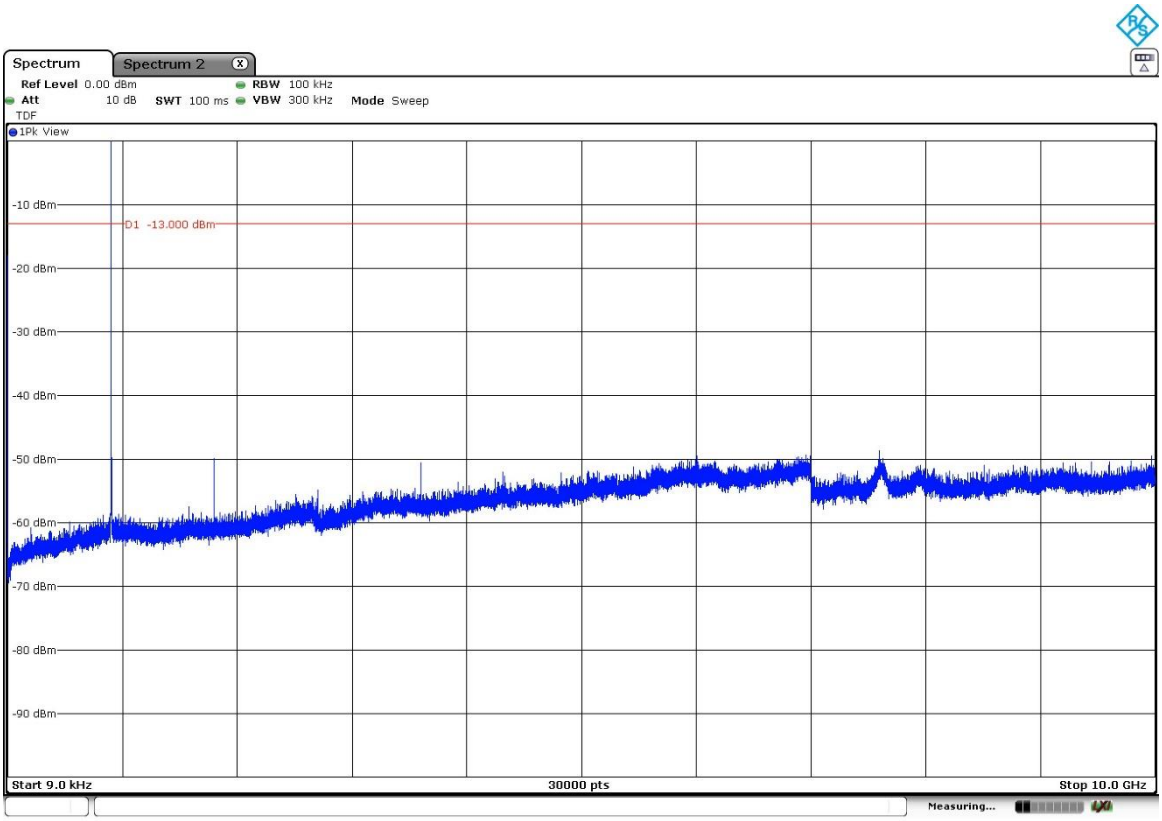
Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE




Note: The peak above the limit is the carrier frequency.

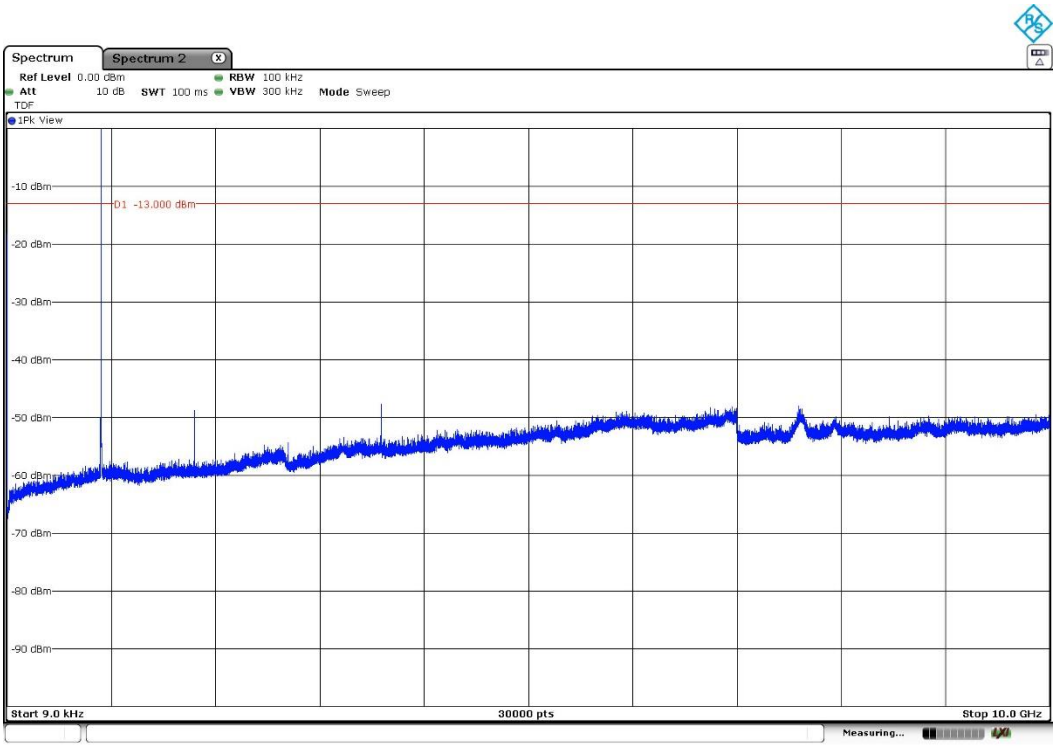
3. CHANNEL: HIGHEST




Note: The peak above the limit is the carrier frequency.

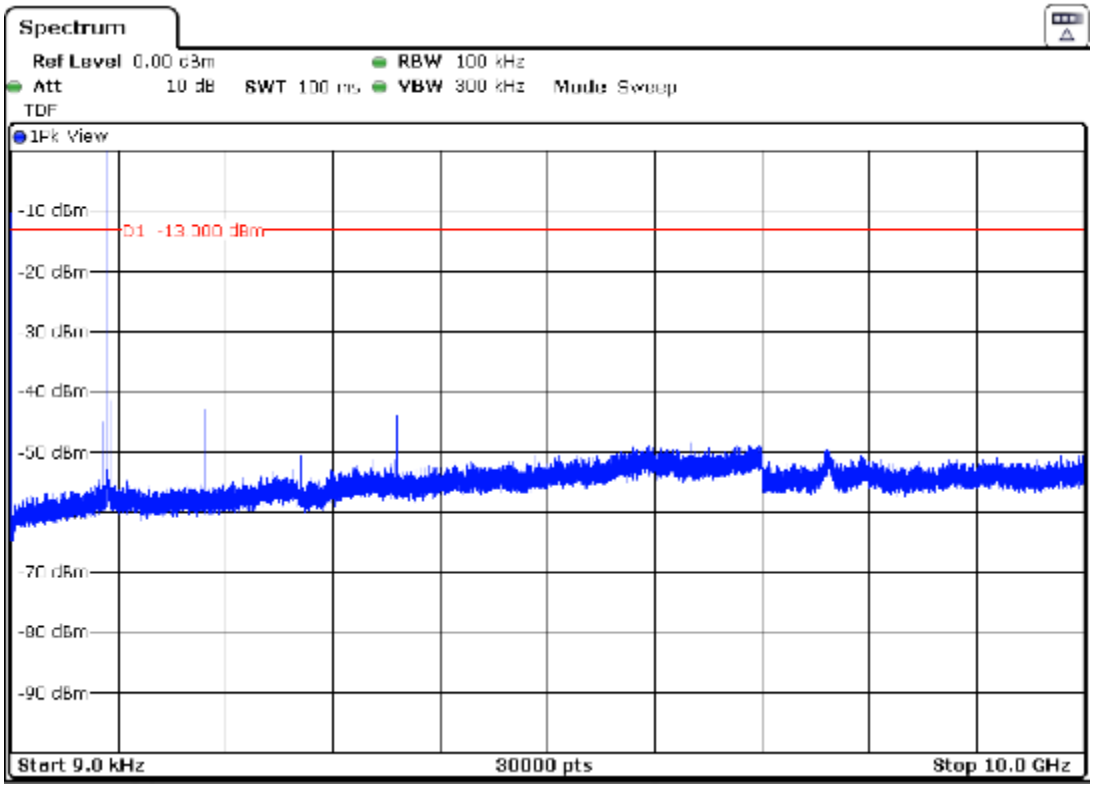
LTE NB-IoT Band 8. PI/4 – QPSK. 1 tone of 3.75 kHz

1. CHANNEL: LOWEST



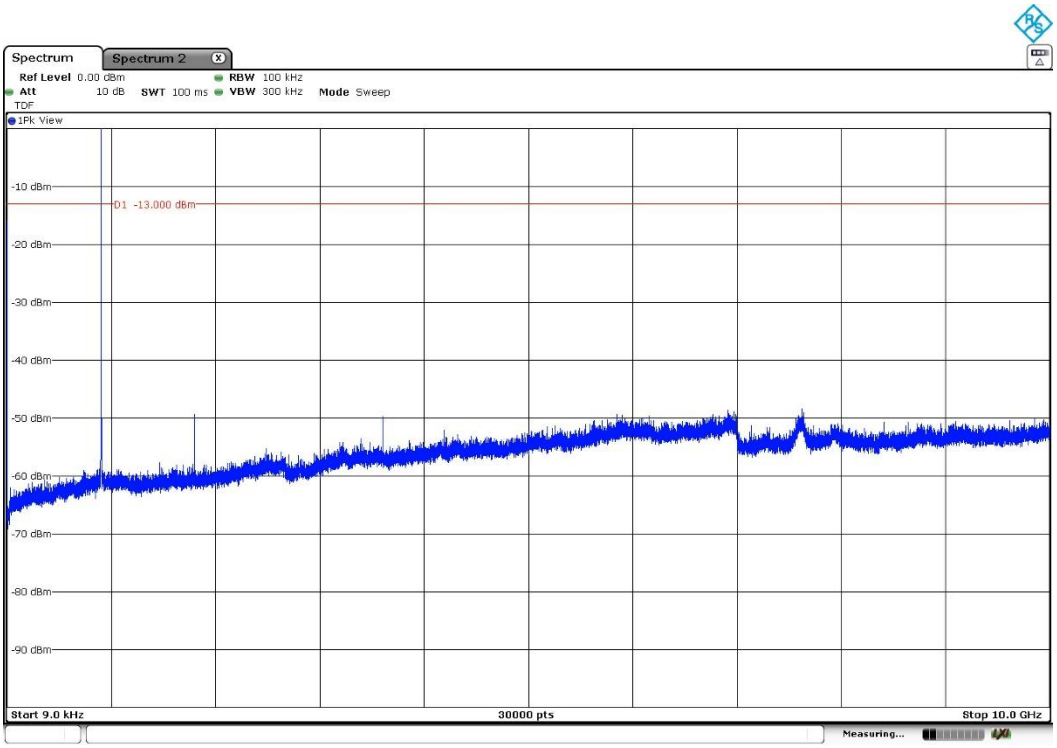

Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE




Note: The peak above the limit is the carrier frequency.

3. CHANNEL: HIGHEST




Note: The peak above the limit is the carrier frequency.

# Spurious emissions at antenna terminals at Block Edges

## SPECIFICATION

**LTE Cat M1 Band 8. LTE NB-IoT Band 8**. FCC Subpart P §27.1509 (a):

FCC §27.1509 (a):

(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:

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

## METHOD

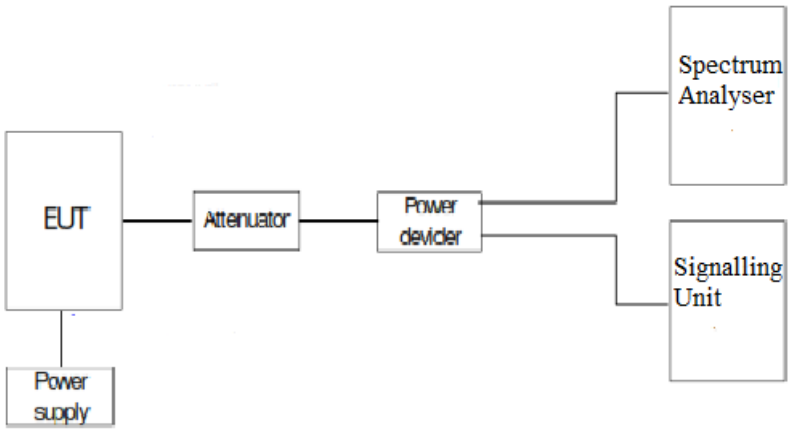
The EUT RF output connector was connected to a spectrum analyser and to the Universal Radio Communication tester R&S CMW500 (selecting maximum transmission power of the EUT and different modes of modulation) using a 50 ohm attenuator and a power splitter.

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

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

For LTE Band 8, as indicated in FCC part 27.1509 (c), in the 100 kHz bands immediately outside and adjacent to the licensee's band, a resolution bandwidth of 30 kHz may be employed.

## TEST SETUP



RESULTS

LTE Cat. M1 Band 8

Preliminary measurements determined the narrow band = 0 and nominal bandwidth of 1.4 MHz as the worst case. The results in the next tables shows the results for this configuration.

| (Channels in Band 8): | RB=1. Offset=0. Narrow band = 0 BW=1.4 MHz | RB= All. Offset=0. Narrow band = 0 BW=1.4 MHz |
|---|---|---|
| Maximum measured level at lowest Block Edge at antenna port (dBm) | -26.29 | -36.14 |

| (Channels in Band 8): | RB= 1. Offset=Max. Narrow band = 0 BW=1.4 MHz | RB= All. Offset=0. Narrow band = 0 BW=1.4 MHz |
|---|---|---|
| Maximum measured level at highest Block Edge at antenna port (dBm) | -33.24 | -34.69 |

LTE NB-IoT Band 8

The results in the next tables shows the results for this configuration.

| (Channels in Band 8): | 1 tone of 3.75kHz Pi/2-BPSK Offset=0 MCS/TBS=0 | 1 tone of 15kHz Pi/2-BPSK Offset=0 MCS/TBS=0 | 12 tones of 15kHz Pi/4-QPSK Offset=0 MCS/TBS=5 |
|---|---|---|---|
| Maximum measured level at lowest Block Edge at antenna port (dBm) | -23,86 | -38,1 | -27,67 |

| (Channels in Band 8): | 1 tone of 3.75kHz Pi/2-BPSK Offset=47 MCS/TBS=0 | 1 tone of 15kHz Pi/2-BPSK Offset=11 MCS/TBS=0 | 12 tones of 15kHz Pi/4-QPSK Offset=0 MCS/TBS=5 |
|---|---|---|---|
| Maximum measured level at highest Block Edge at antenna port (dBm) | -26,96 | -32,89 | -27,44 |

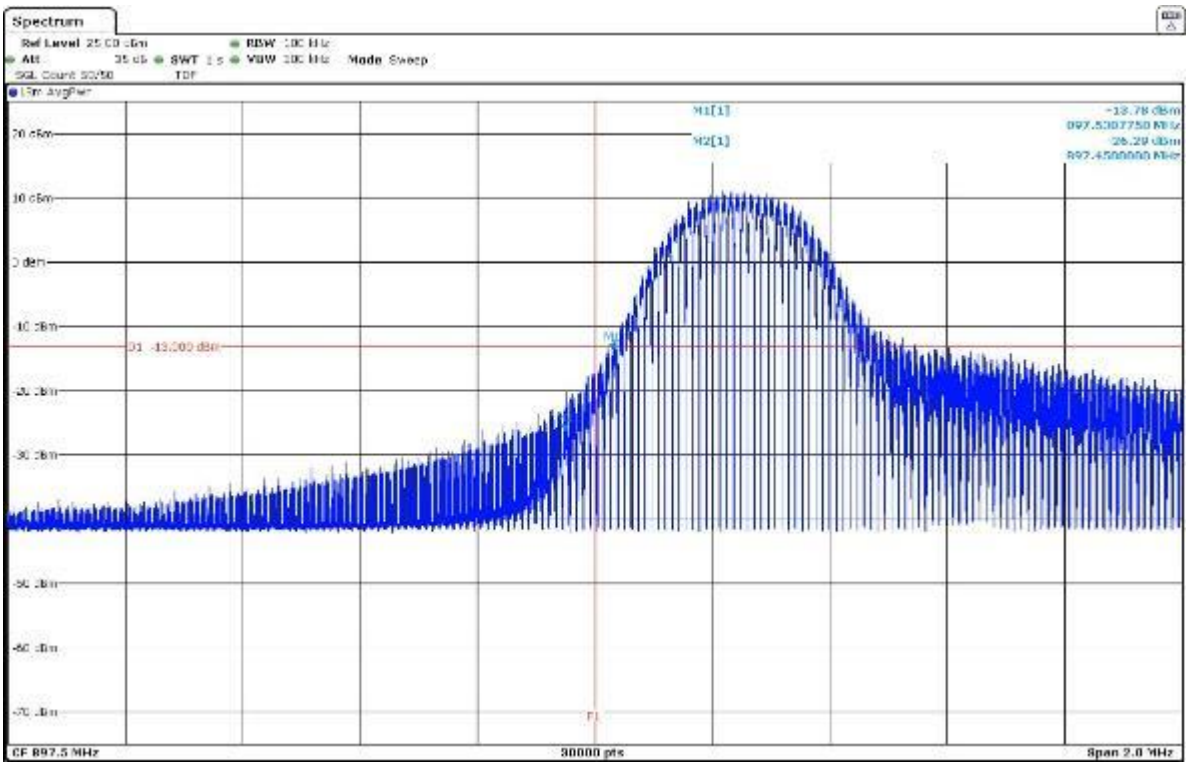
Measurement uncertainty = <±2.76 dB.

Verdict: Pass

LTE Cat. M1 Band 8

Narrow band = 0. RB = 1. Offset = 0. BW = 1.4 MHz

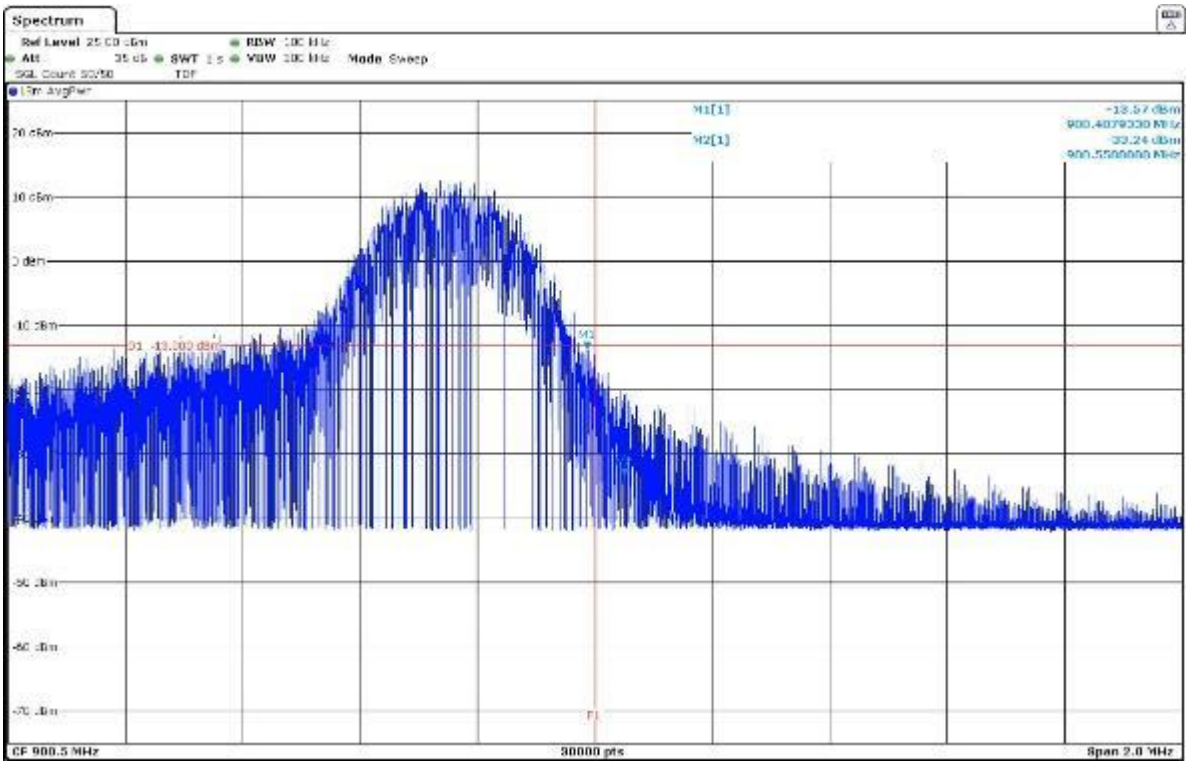
CHANNEL LOWEST




NOTE: The equipment transmits at the maximum output power

Narrow band = 0. RB = 1. Offset = Max. BW = 1.4 MHz

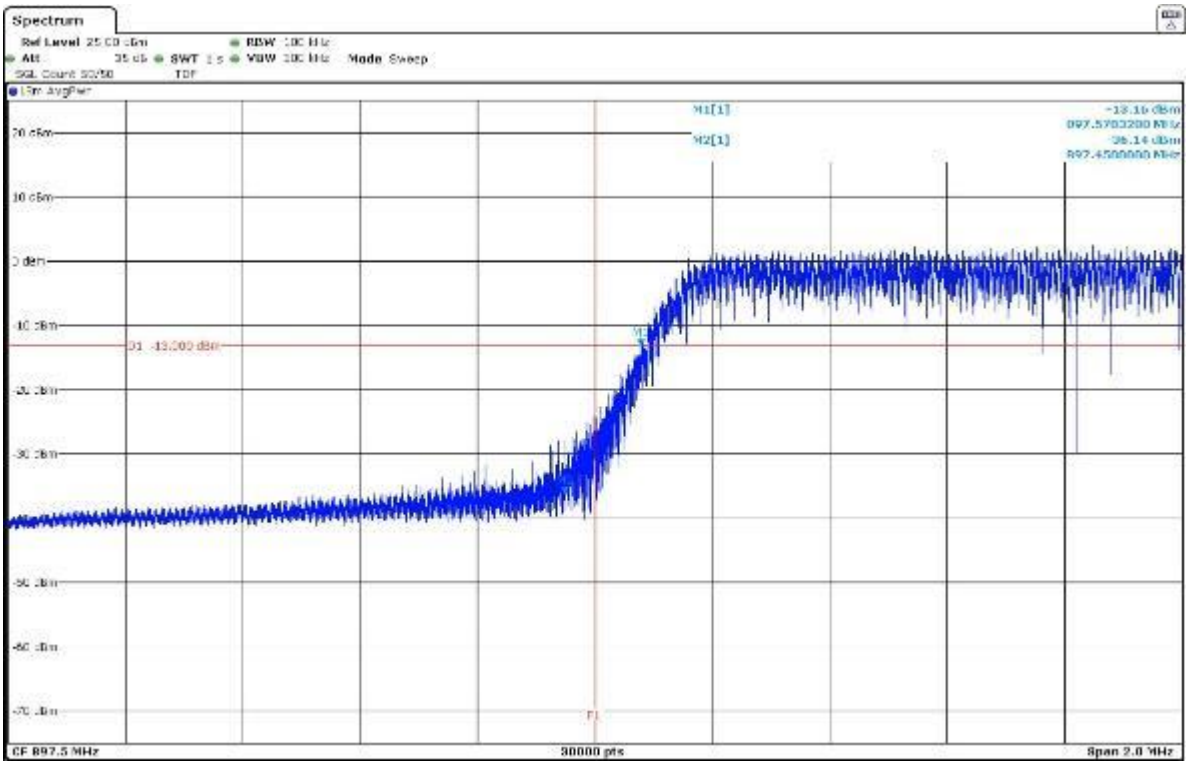
CHANNEL HIGHEST




NOTE: The equipment transmits at the maximum output power

Narrow band = 0. RB = All. Offset = 0. BW = 1.4 MHz

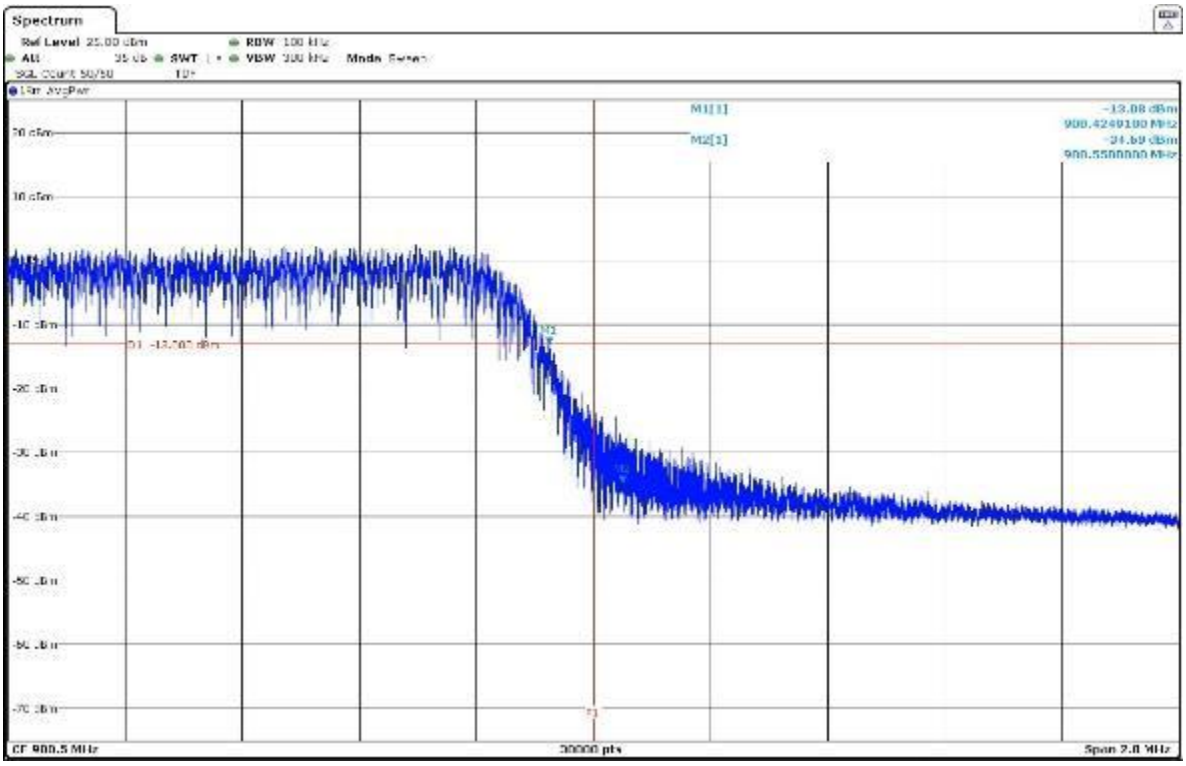
CHANNEL LOWEST




NOTE: The equipment transmits at the maximum output power

Narrow band = 0. RB = All. Offset = 0. BW = 1.4 MHz

CHANNEL HIGHEST



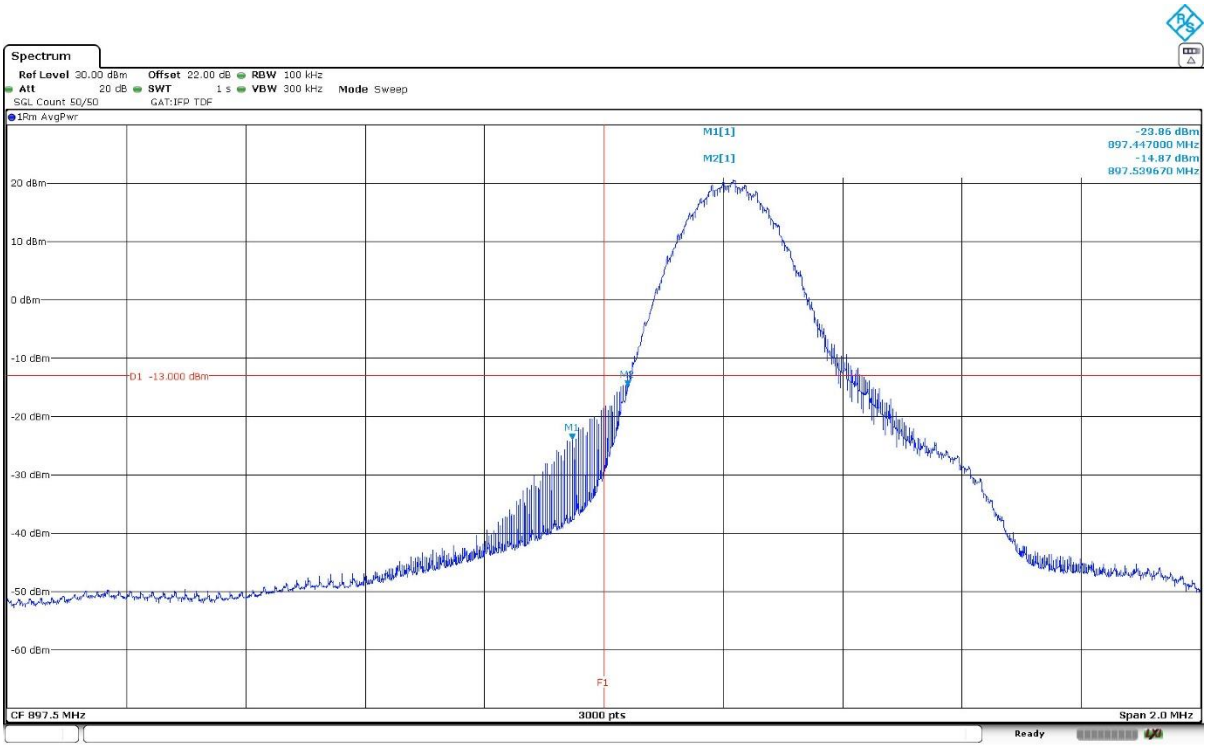

NOTE: The equipment transmits at the maximum output power

Verdict: Pass

LTE NB-IoT Band 8

1 tone of 3.75kHz, Pi/2-BPSK. Offset=0, MCS / TBS=0

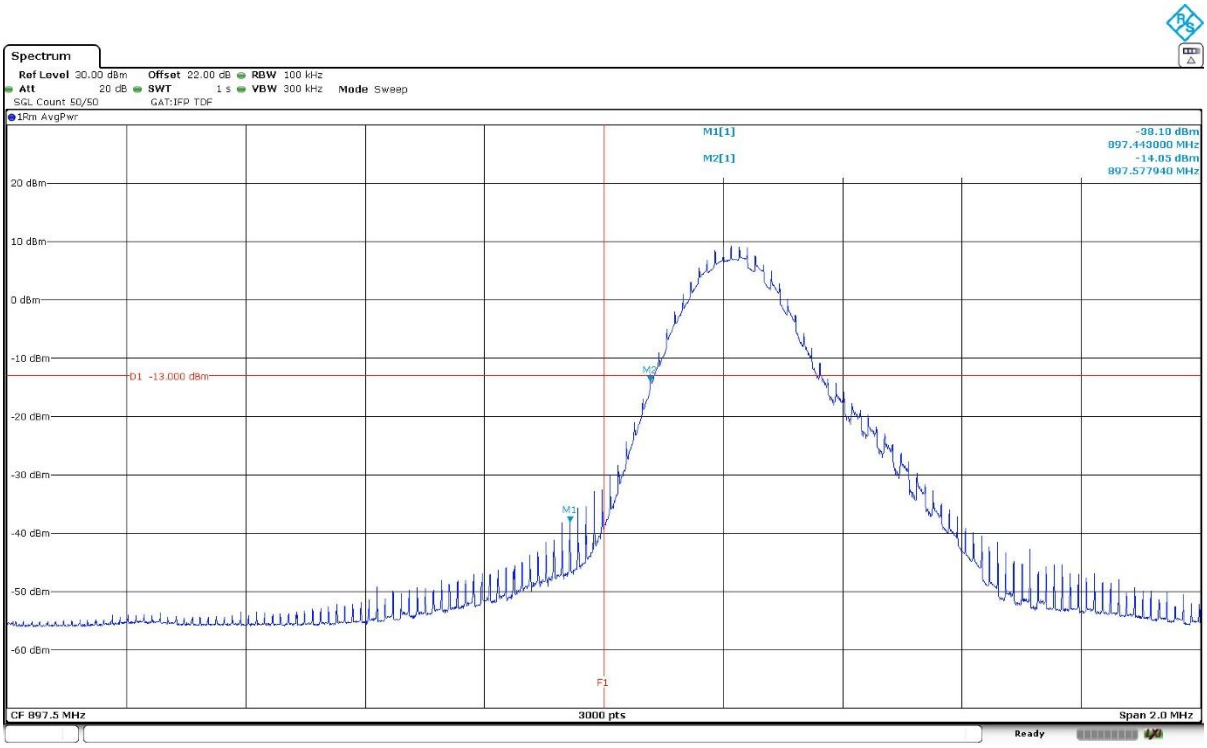
CHANNEL LOWEST




NOTE: The equipment transmits at the maximum output power

1 tone of 15kHz, Pi/2-BPSK. Offset=0, MCS / TBS=0

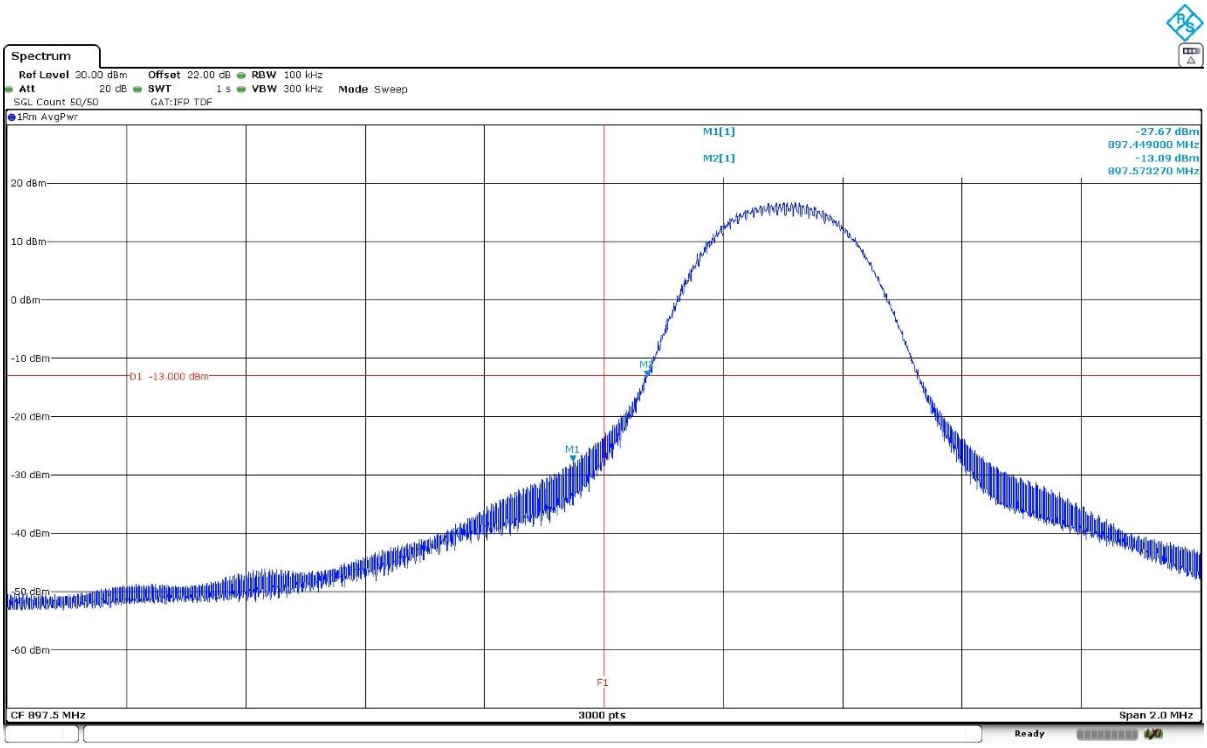
CHANNEL LOWEST




NOTE: The equipment transmits at the maximum output power

12 tones of 15kHz, Pi/2-BPSK. Offset=0, MCS / TBS=0

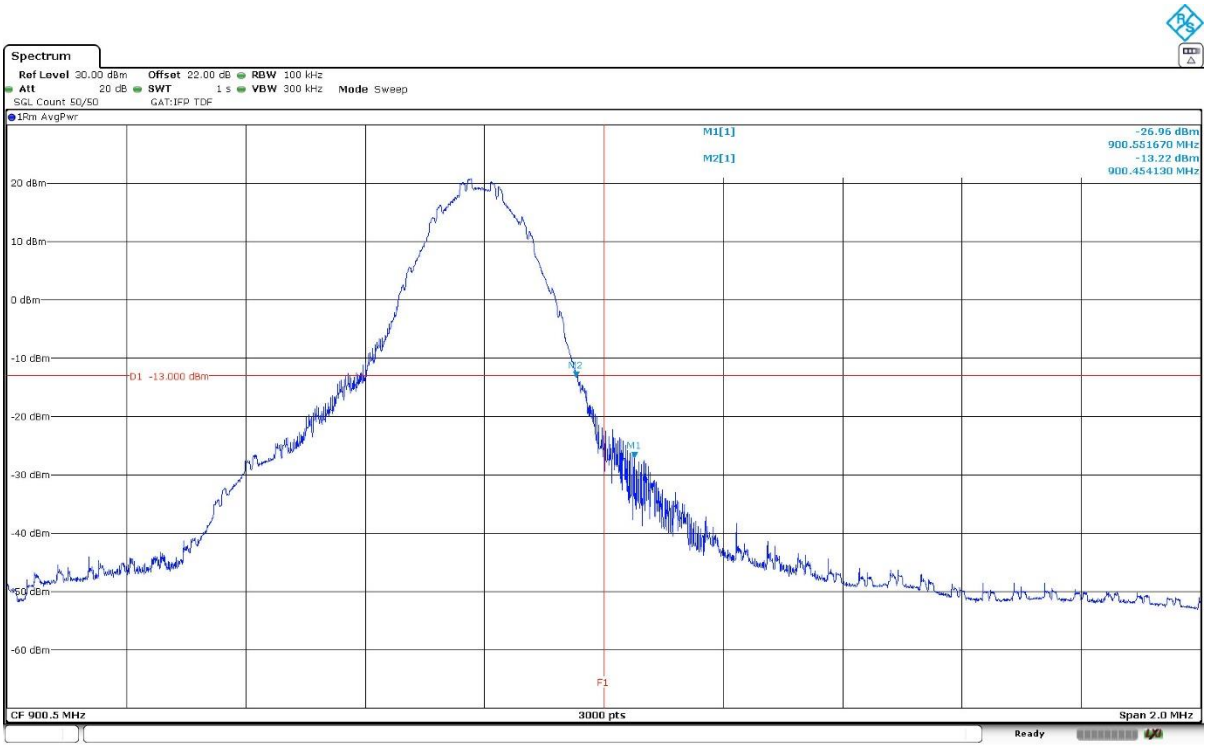
CHANNEL LOWEST




NOTE: The equipment transmits at the maximum output power

1 tone of 3.75kHz, Pi/2-BPSK. Offset=47, MCS / TBS=0

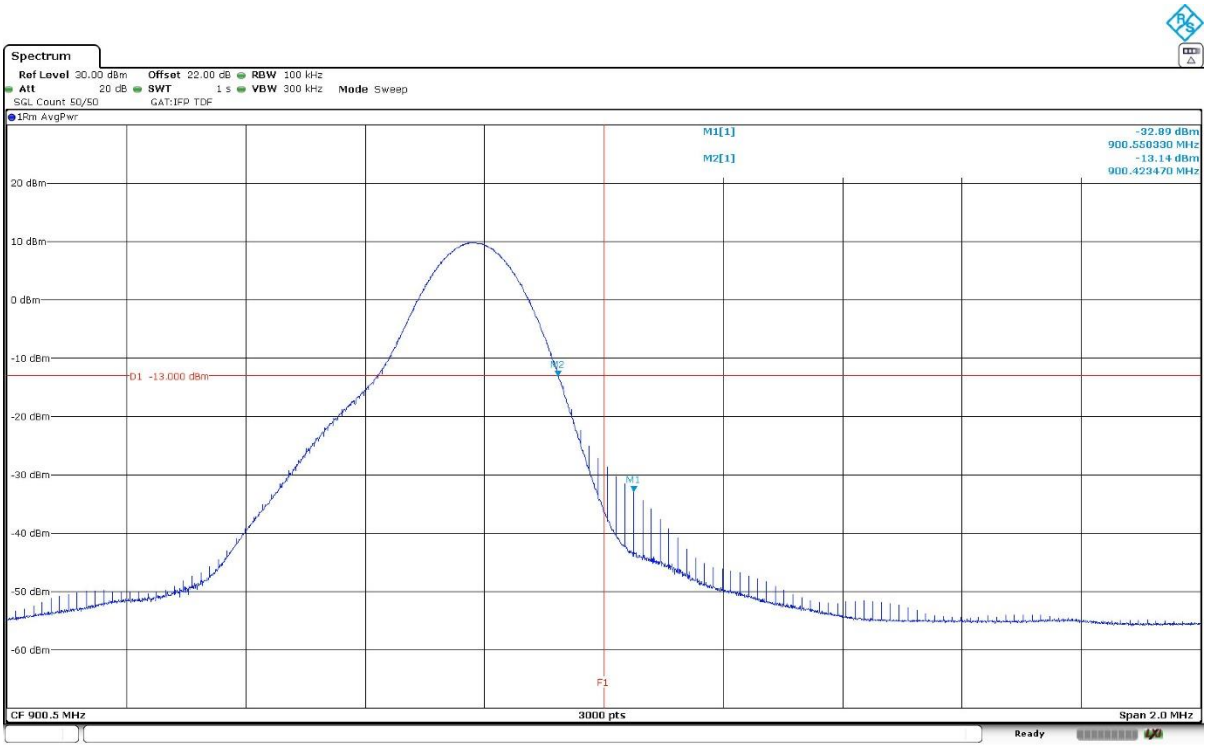
CHANNEL HIGHEST.




NOTE: The equipment transmits at the maximum output power

1 tone of 15kHz, Pi/2-BPSK. Offset=11, MCS / TBS=0

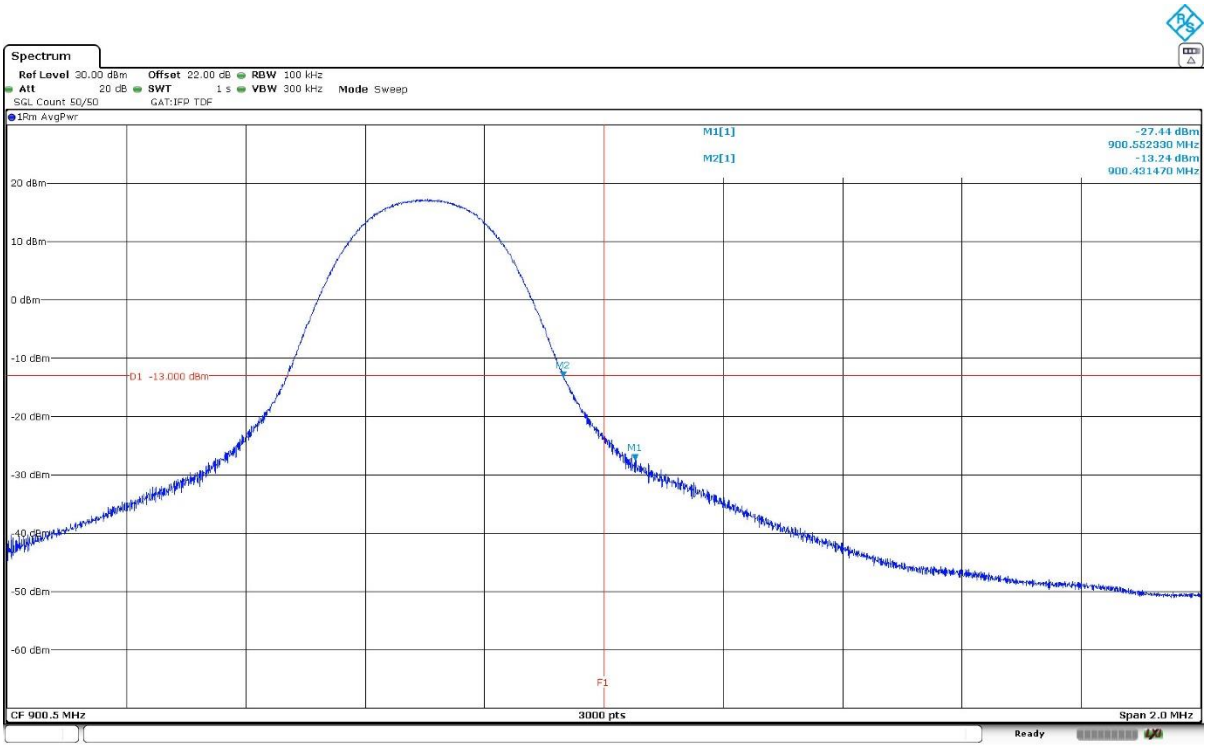
CHANNEL HIGHEST.




NOTE: The equipment transmits at the maximum output power

12 tone of 15kHz, Pi/4-QPSK. Offset=0, MCS / TBS=5

CHANNEL HIGHEST.




NOTE: The equipment transmits at the maximum output power

Verdict: PASS

# Radiated Emissions

SPECIFICATION:

**LTE Cat M1 Band 8. LTE NB-IoT Band 8**. FCC Subpart P §27.1509 (a):

FCC §27.1509 (a):

> (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:
>
> For 900 MHz broadband operations in 897.5-900.5 MHz band by at least 43 + 10 log (P) dB.

METHOD:

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

The EUT was placed on a non-conductive stand at a 3 meter distance from the measuring antenna for measurements from 30 MHz up to 10 GHz.

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

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

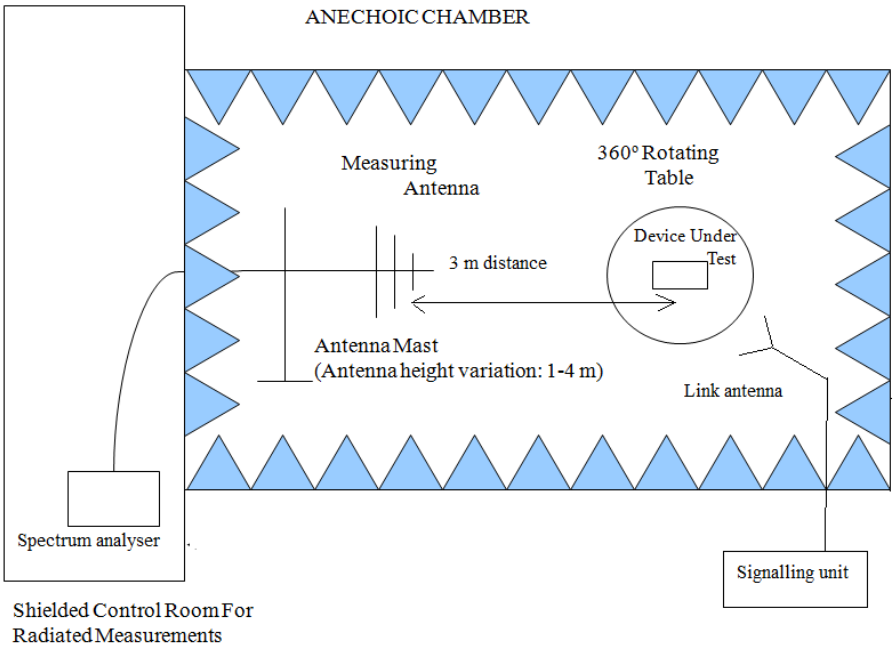
$$EIRP\ (dBm) = E(dB\mu V/m) + 20 \log (D) - 104.8$$

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

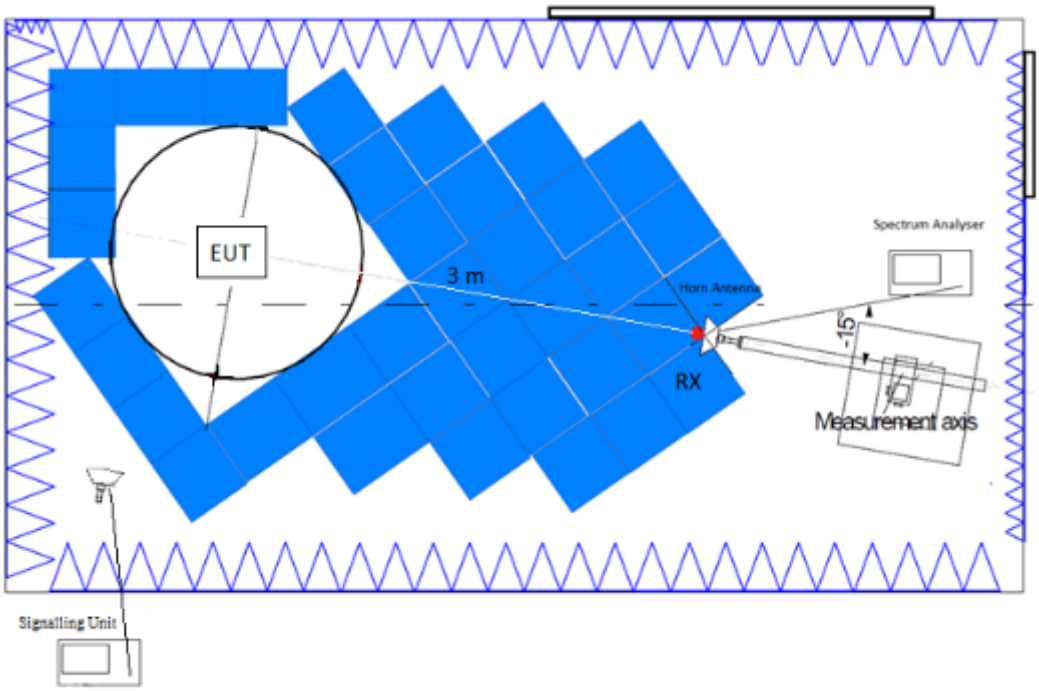
A resolution bandwidth / video bandwidth of 100 kHz / 300 kHz was used for frequencies below 1 GHz and 1 MHz / 3 MHz for frequencies above 1 GHz.

TEST SETUP:

Radiated measurements below 1 GHz.




Radiated measurements between 1 GHz and 10 GHz.



RESULTS:

**LTE Cat M1 Band 8:**

A preliminary scan determined the QPSK modulation, Nominal Bandwidth of 1.4 MHz, RB Size 1, RB Offset 2 as the worst case. The following tables and plots show the results for this configuration.

**- Low Channel:**

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

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

**Frequency range 1 - 10 GHz:**

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

**- Middle Channel:**

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

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

**Frequency range 1 - 10 GHz:**

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

**- High Channel:**

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

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

**Frequency range 1 - 10 GHz:**

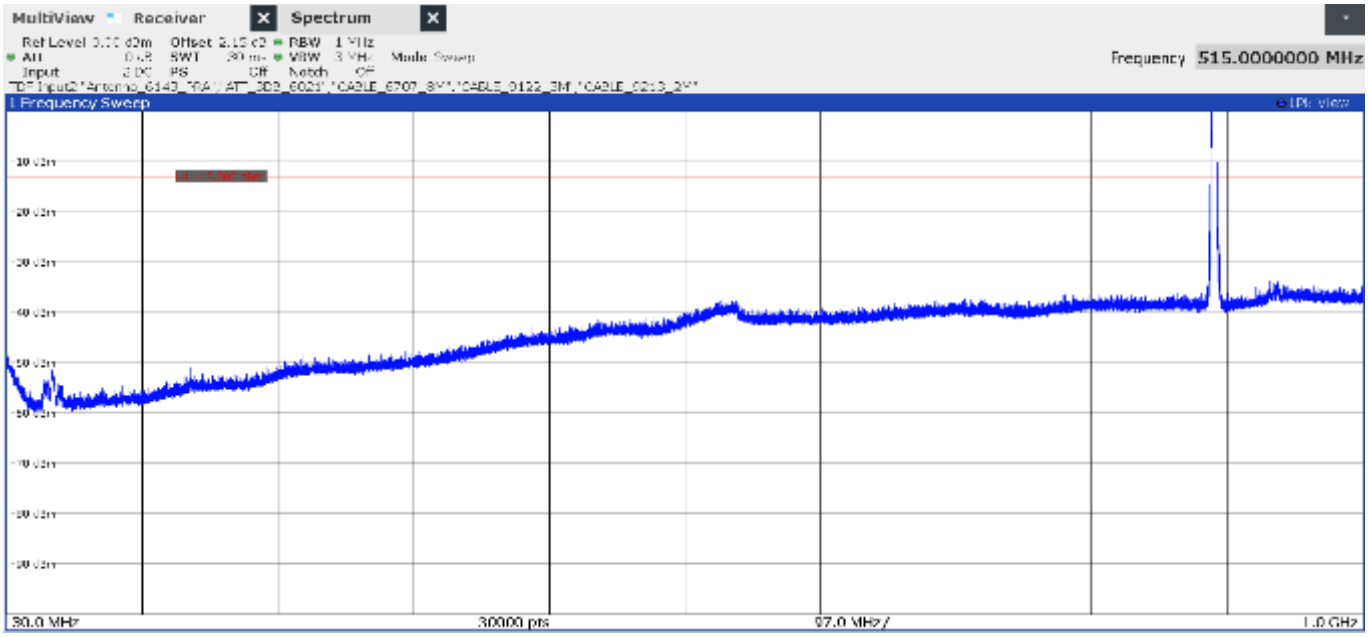
No spurious frequencies at less than 20 dB below the limit.

| | |
|---|---|
| Measurement Uncertainty (dB): | <± 4.90 for f ≥ 30 MHz up to 1 GHz<br><± 4.32 for f ≥ 1 GHz up to 10 GHz |

Verdict: PASS

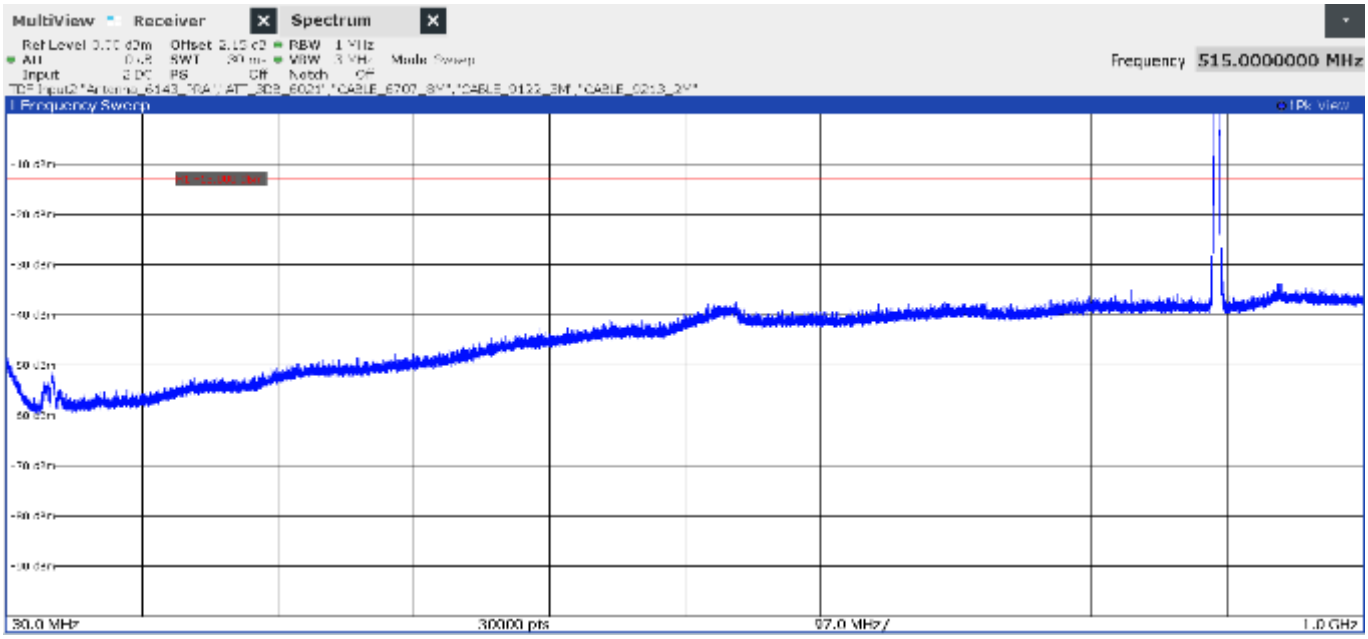
## FREQUENCY RANGE 30 MHz - 1 GHz:

- Low Channel:



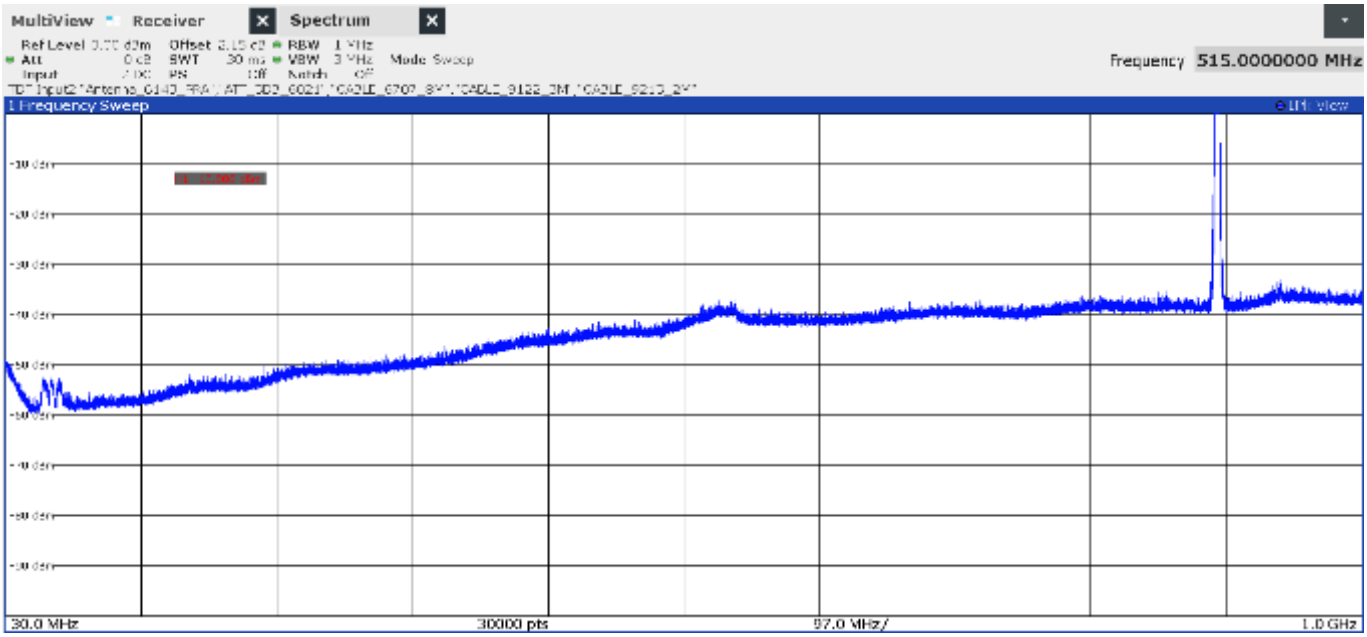

The peak above the limit is the carrier frequency.

- Middle Channel:




The peak above the limit is the carrier frequency.

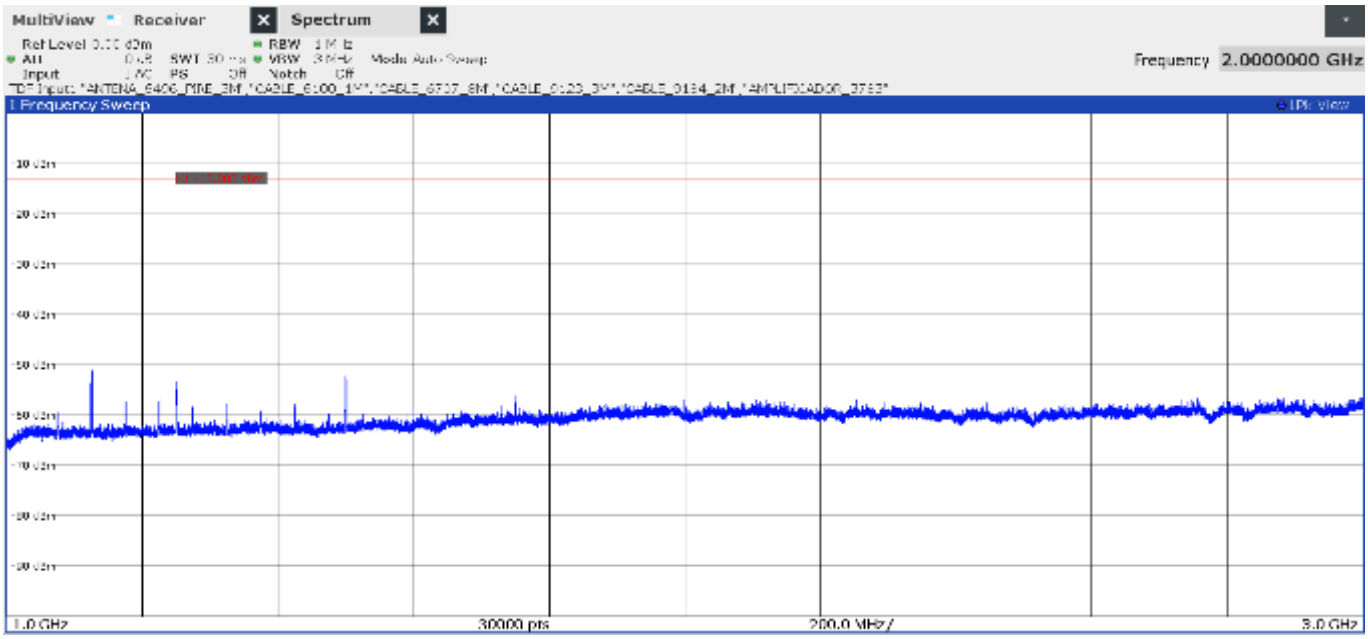
- High Channel:



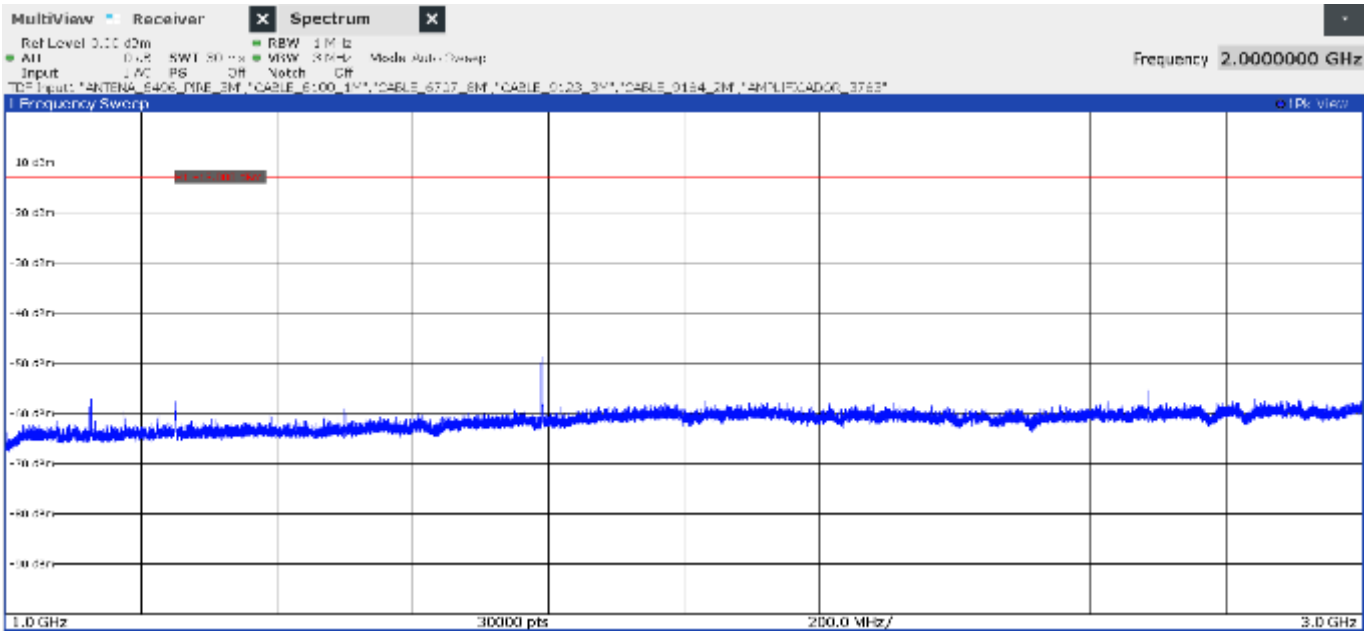

The peak above the limit is the carrier frequency.

## FREQUENCY RANGE 1 - 3 GHz:

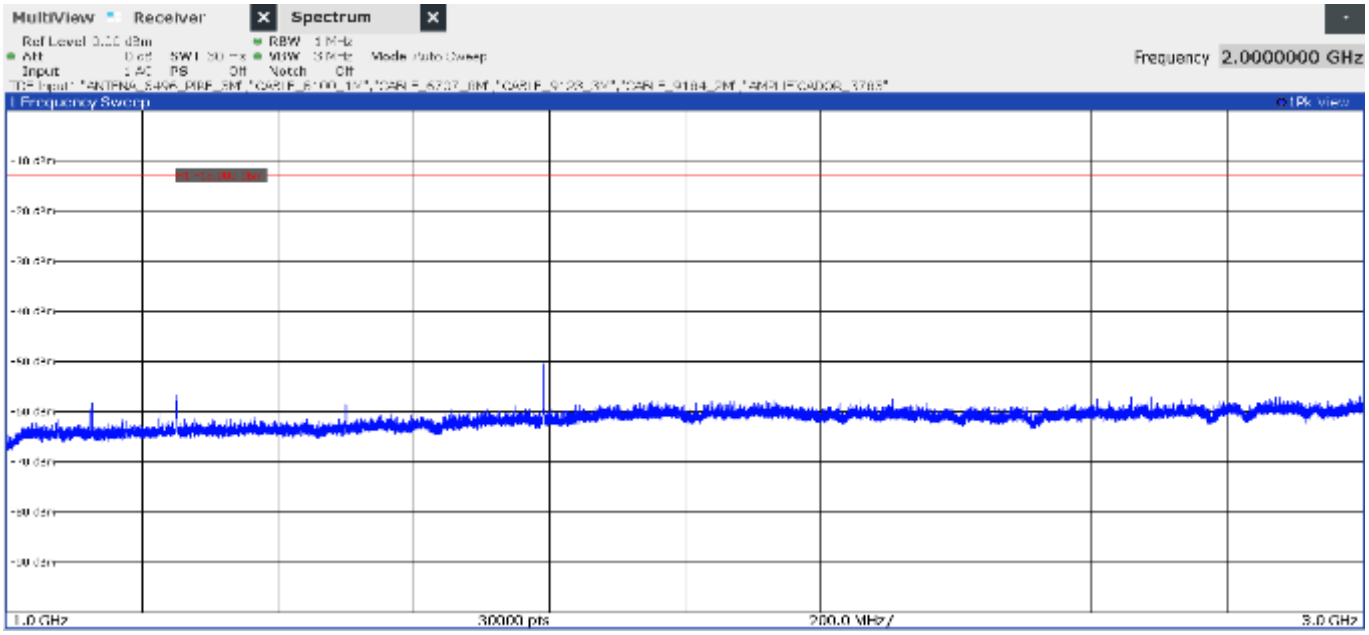
- Low Channel:



- Middle Channel:

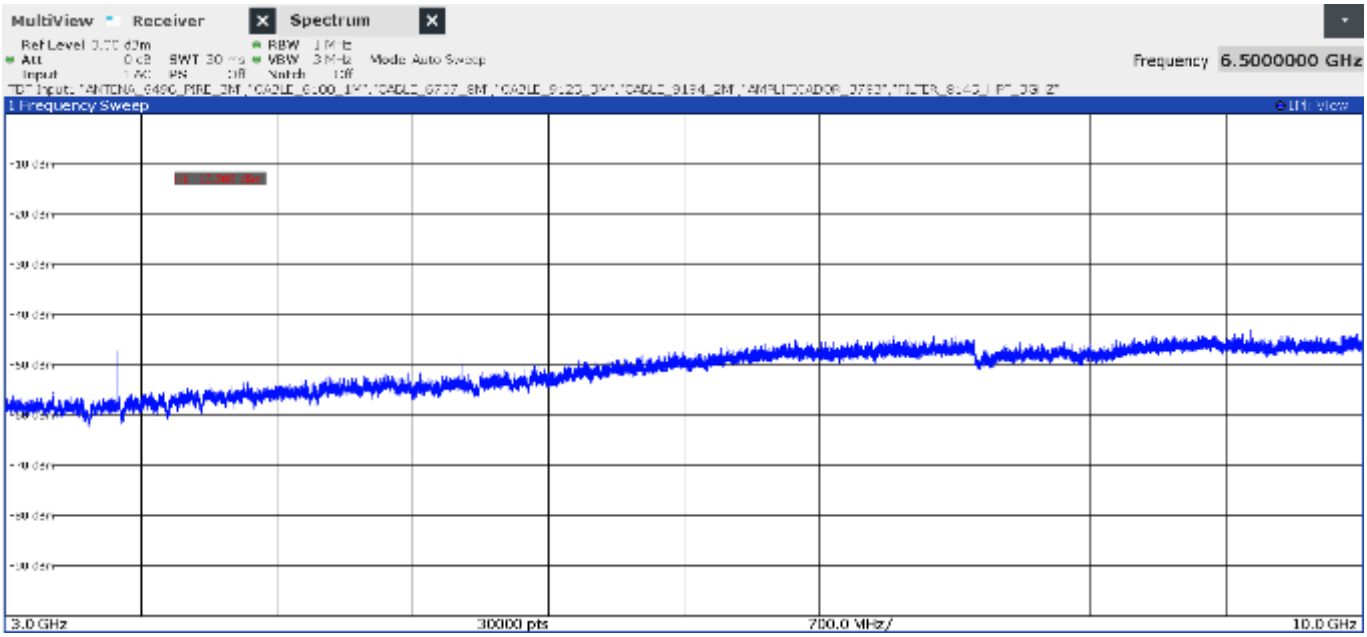



- High Channel:

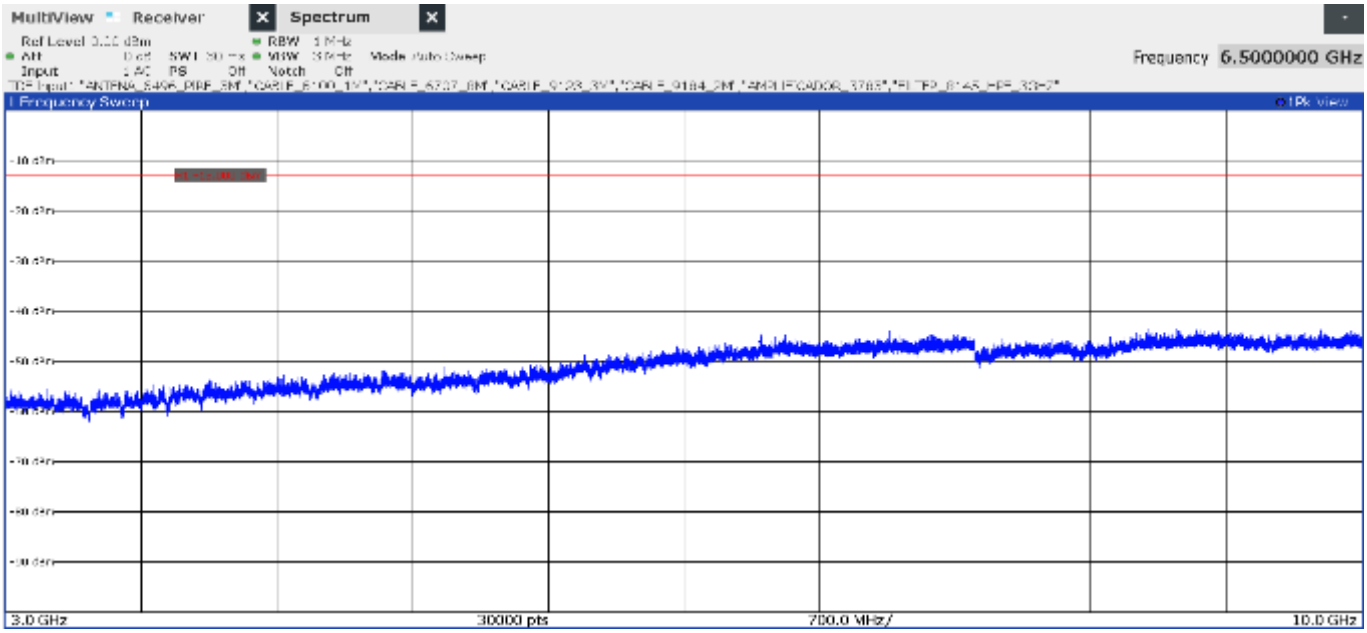


## FREQUENCY RANGE 3 - 10 GHz:

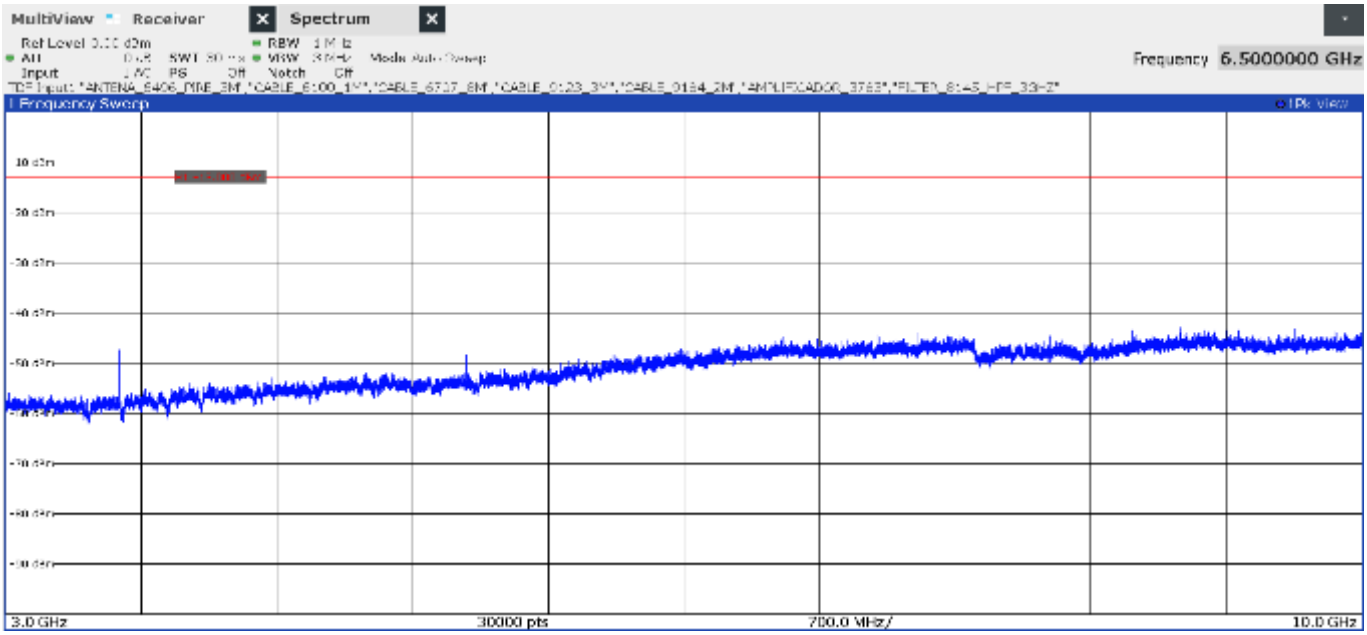
- Low Channel:




- Middle Channel:



- High Channel:



**LTE NB-IoT Band 8:**

A preliminary scan determined the pi/4-QPSK modulation, Tone Number 1, Tone Channel Bandwidth 3.75 kHz, TBS 3, Tone Offset 0 as the worst case. The following tables and plots show the results for this configuration.

**- Low Channel:**

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

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

**Frequency range 1 - 10 GHz:**

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

**- Middle Channel:**

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

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

**Frequency range 1 - 10 GHz:**

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

**- High Channel:**

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

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

**Frequency range 1 - 10 GHz:**

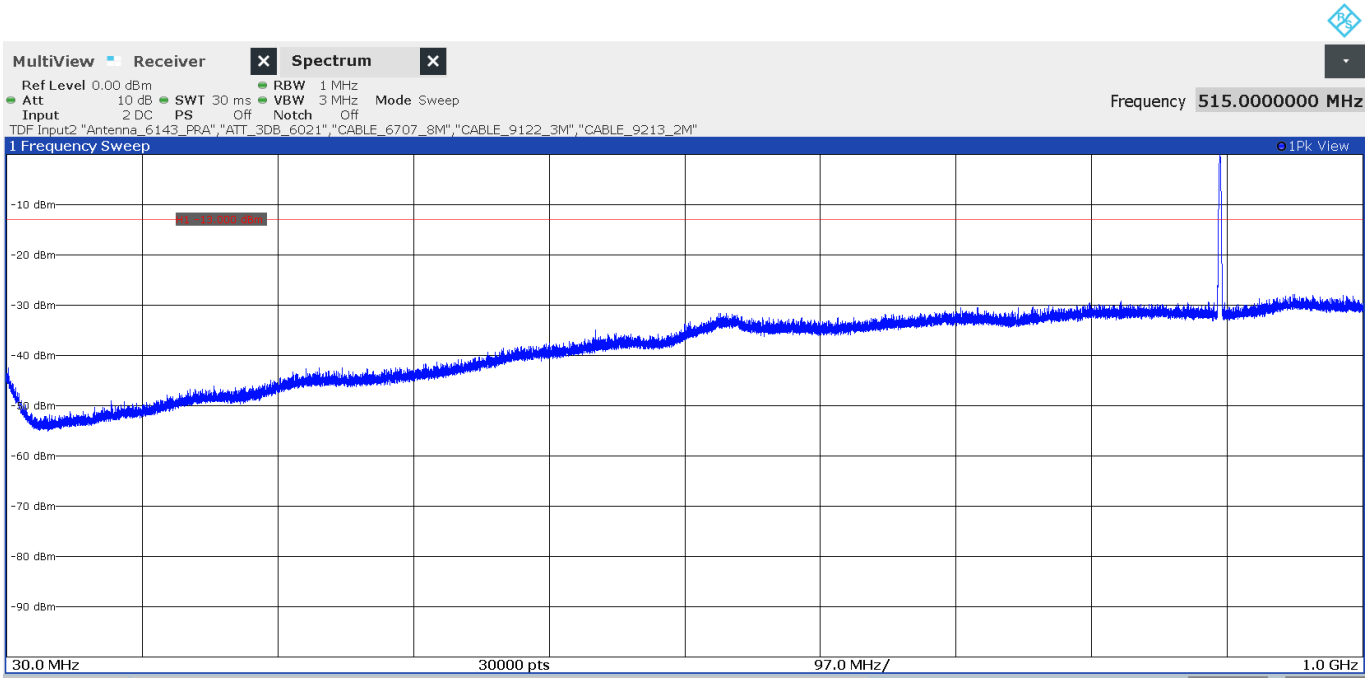
No spurious frequencies at less than 20 dB below the limit.

| | |
|---|---|
| Measurement Uncertainty (dB): | <± 4.90 for f ≥ 30 MHz up to 1 GHz<br><± 4.32 for f ≥ 1 GHz up to 10 GHz |

Verdict: PASS

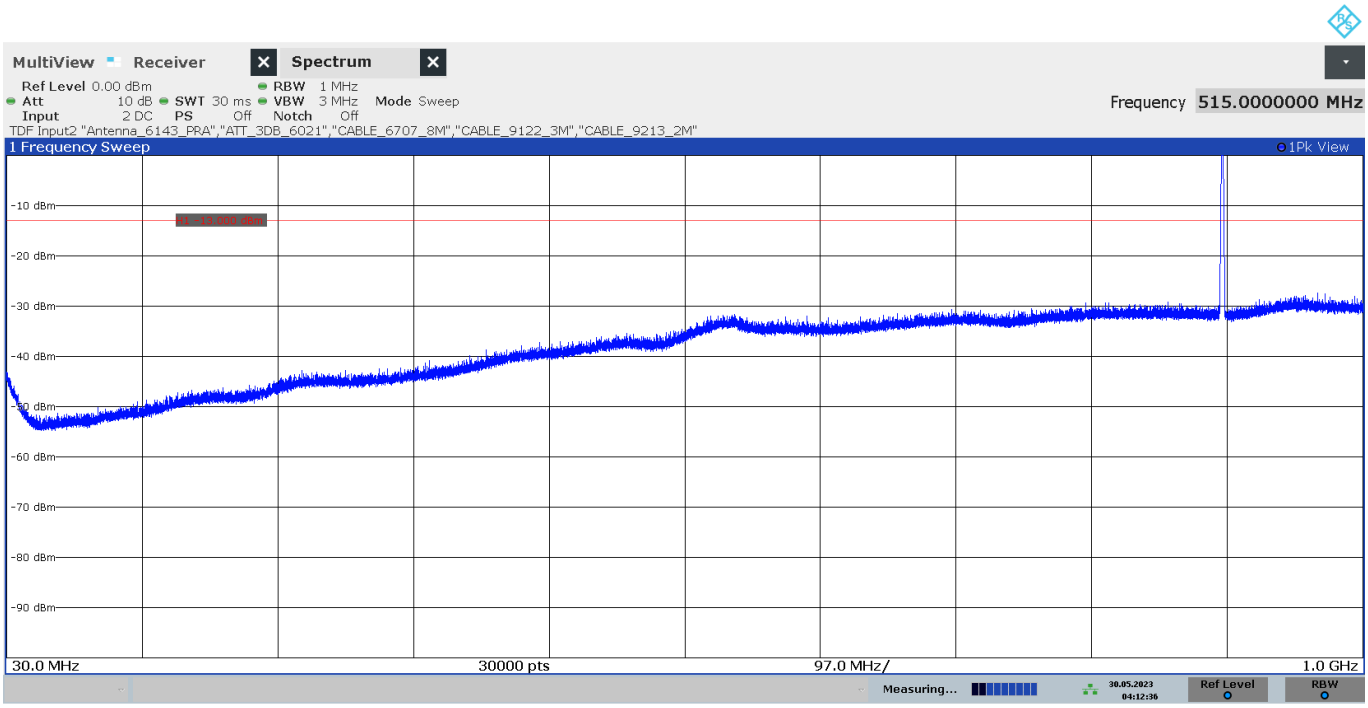
## FREQUENCY RANGE 30 MHz - 1 GHz:

- Low Channel:



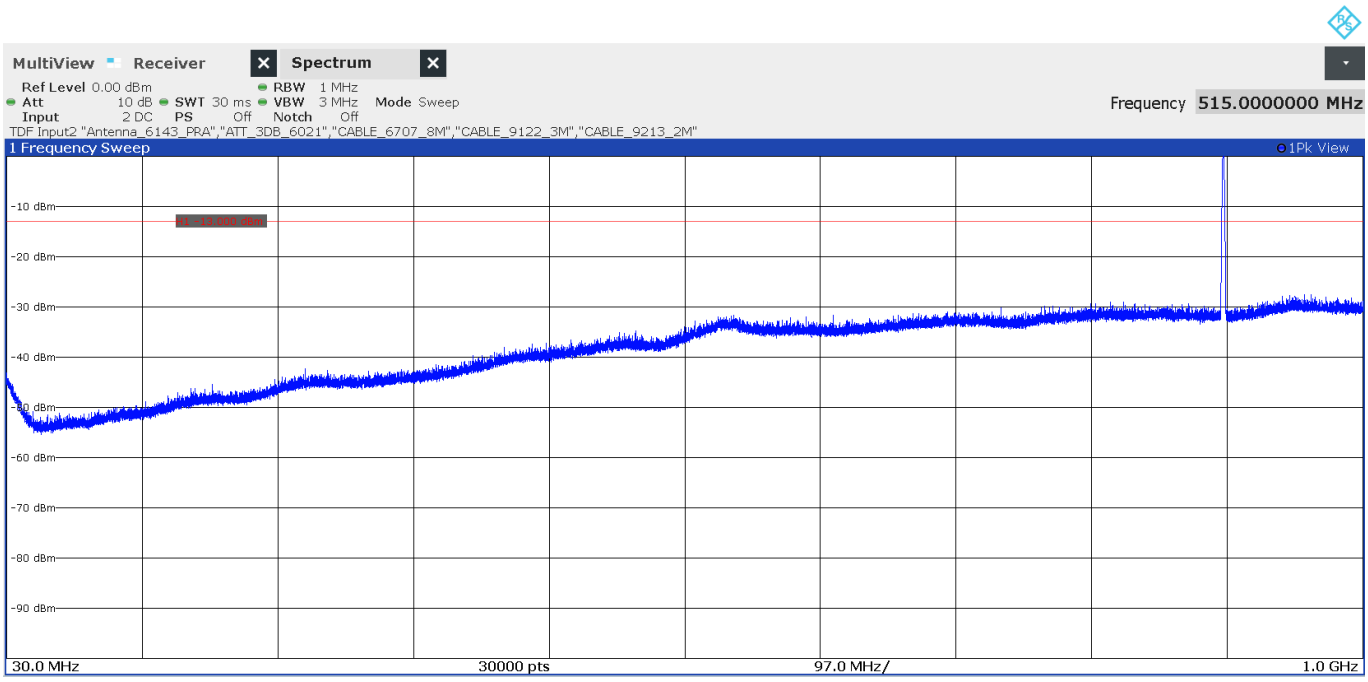

The peak above the limit is the carrier frequency

- Middle Channel:




The peak above the limit is the carrier frequency

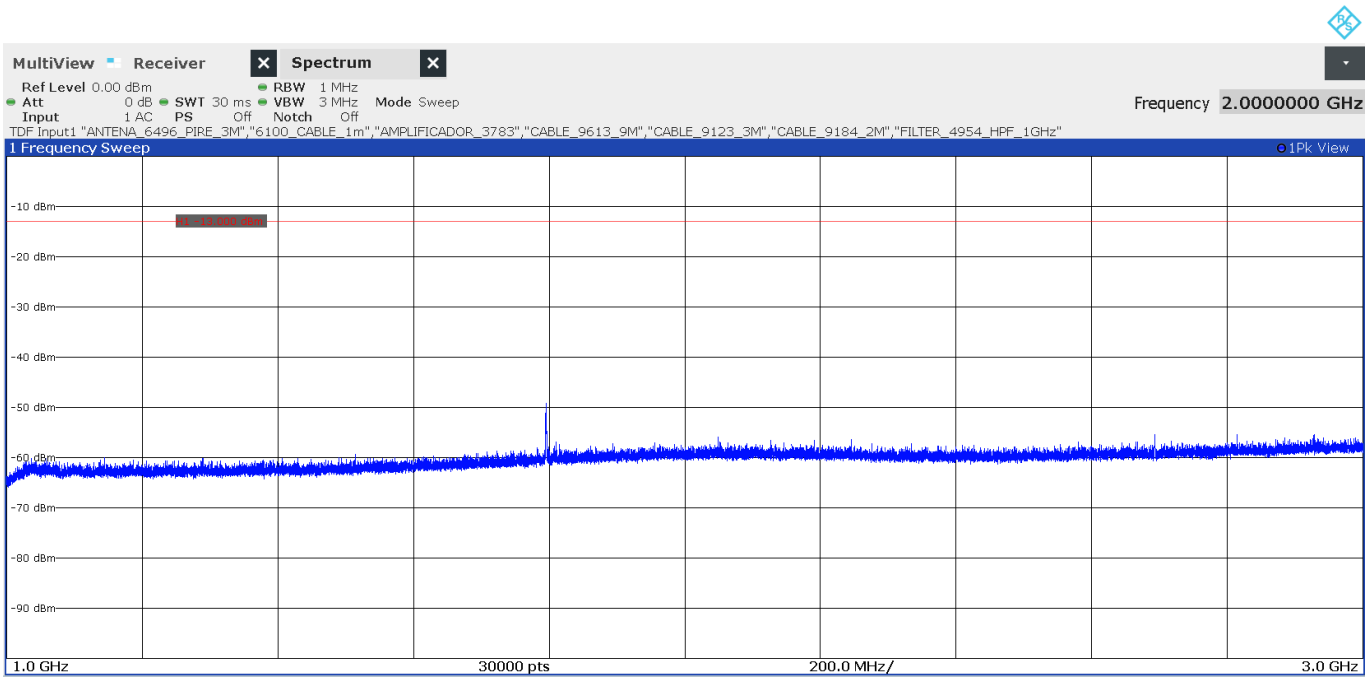
- High Channel:



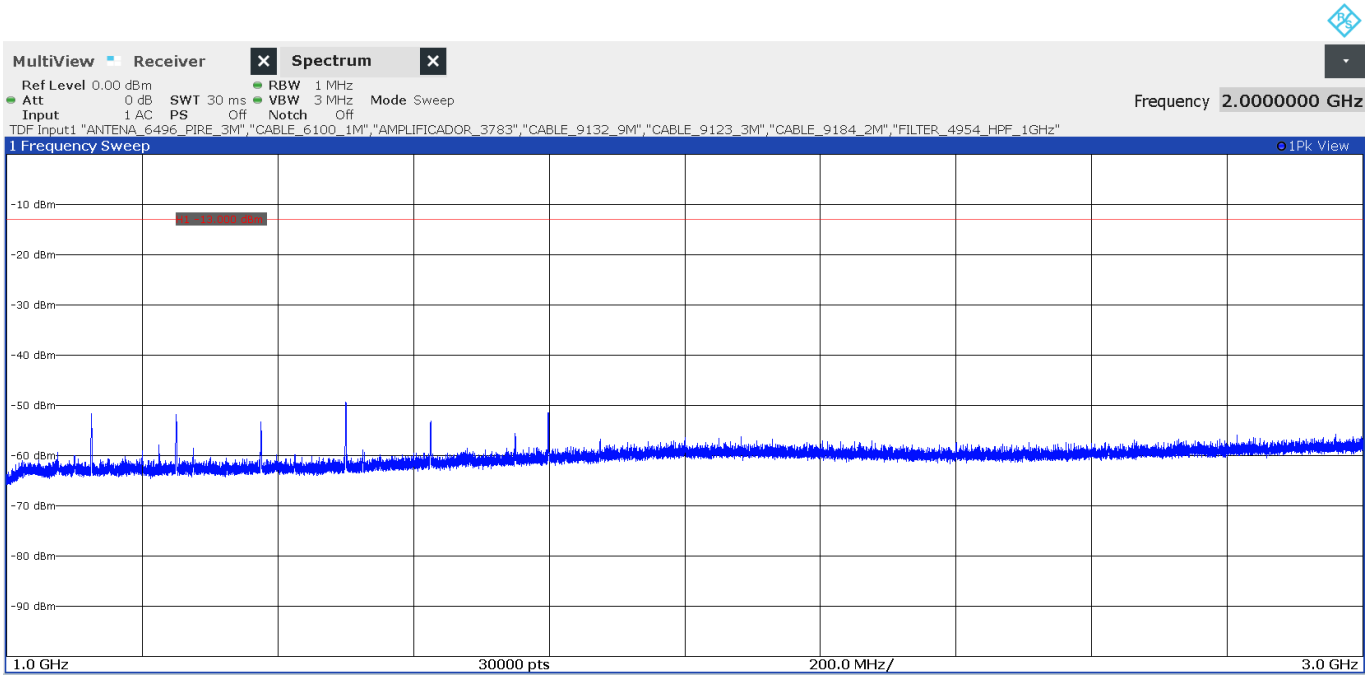

The peak above the limit is the carrier frequency

## FREQUENCY RANGE 1 - 3 GHz:

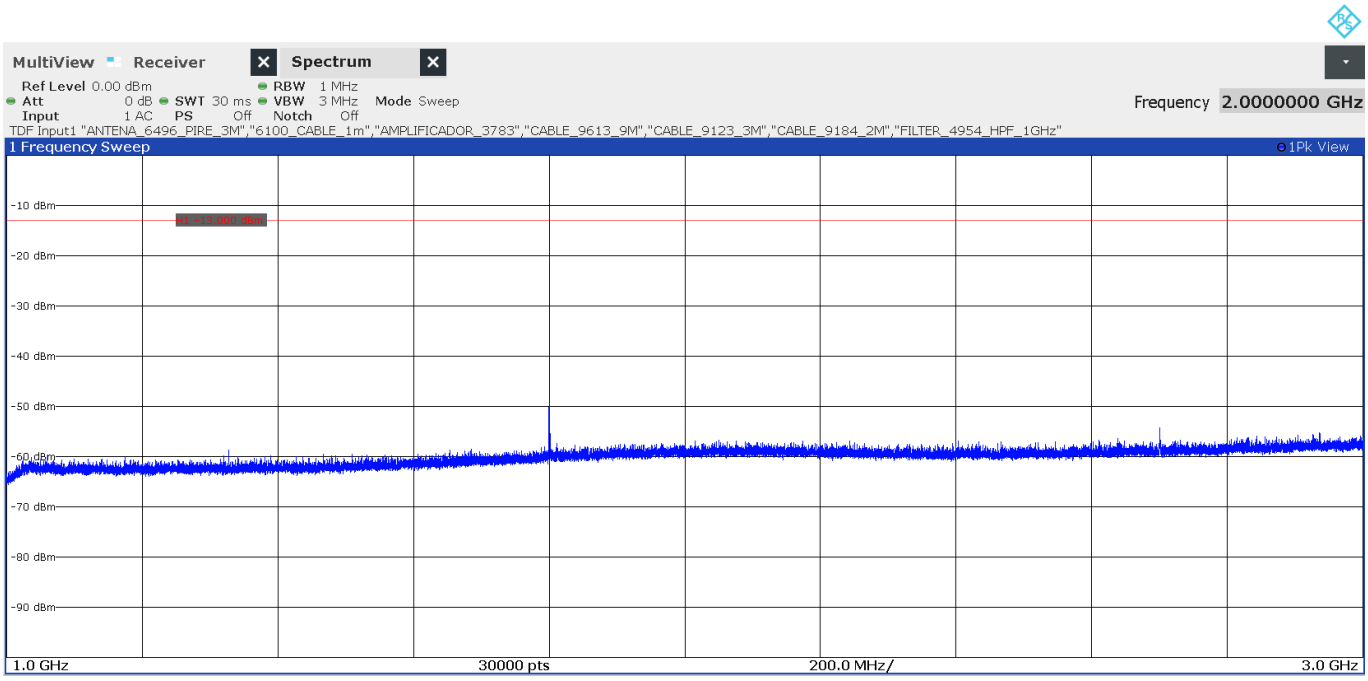
- Low Channel:



- Middle Channel:

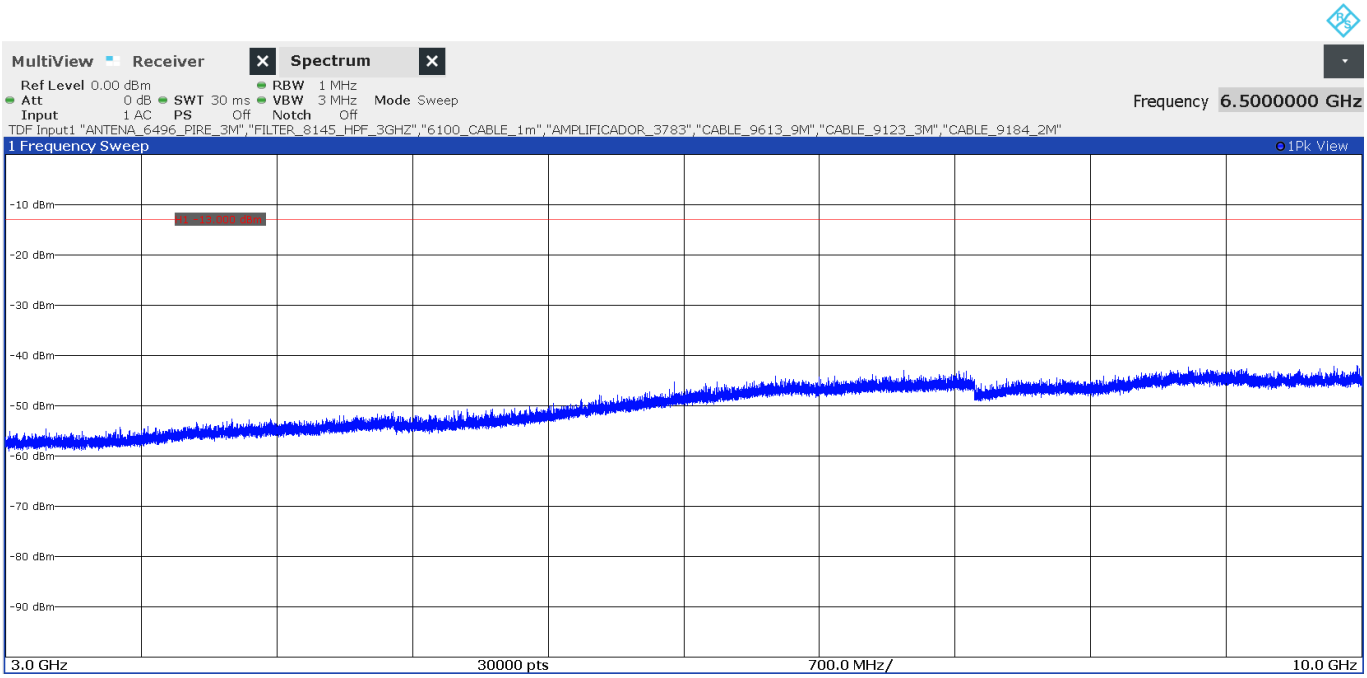



- High Channel:

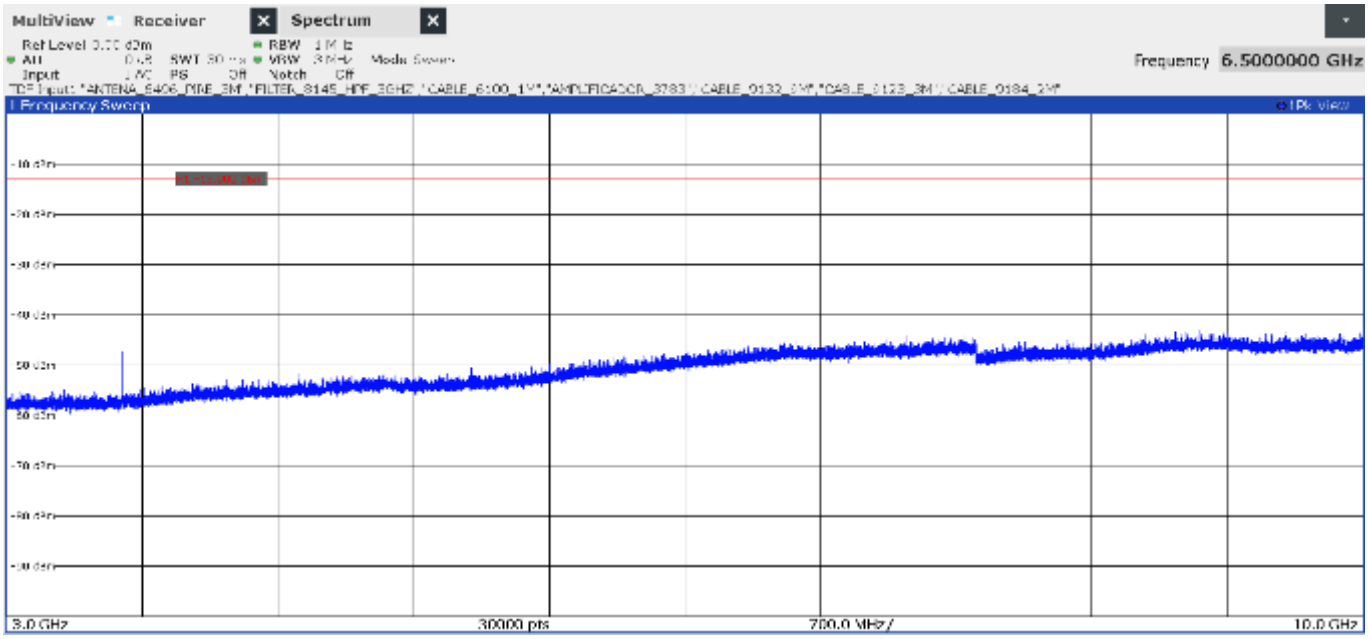
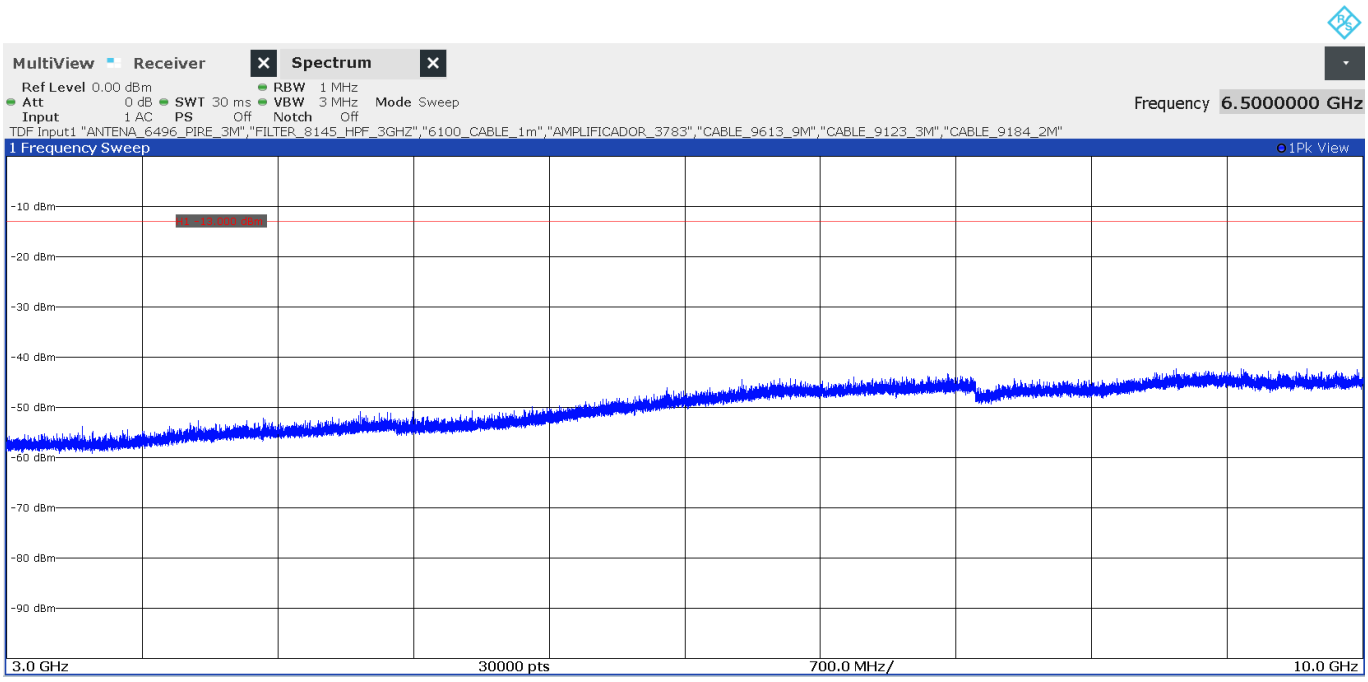


## FREQUENCY RANGE 3 - 10 GHz:

- Low Channel:




- Middle Channel:



- High Channel: