**DEKRA Testing and Certification, S.A.U.**
Parque Tecnológico de Andalucía,
c/ Severo Ochoa nº 2 · 29590 Campanillas · Málaga · España
C.I.F. A29 507 456

FCC LISTED.
REGISTRATION NUMBER:
720267

ISED LISTED
REGISTRATION NUMBER
ISED 4621A-4

Nº 51/LE147

Test report No:
NIE: 59675RRF.002

# Test report

## REFERENCE STANDARD:
## USA FCC Part 24 & Part 27
## CANADA IC RSS-130. RSS-133. RSS-139

| | |
|---|---|
| Identification of item tested | IOT Module |
| Trademark | nRF91 |
| Model and /or type reference | nRF9160 |
| Other identification of the product | FCC ID: 2ANPO00NRF9160<br>IC: 24529-NRF9160<br>IMEI TAC: 35265610 |
| Features | LTE Cat-M1. LTE-NB1. GPS |
| Applicant | Nordic Semiconductor ASA<br>Otto Nielsens Vei 12, 7052 Trondheim, NORWAY |
| Test method requested. standard | USA FCC Part 24 10-1-18 Edition.<br>USA FCC Part 27 10-1-18 Edition.<br>CANADA IC RSS-130 Issue 1. Oct. 2013.<br>CANADA IC RSS-133 Issue 6. Jan. 2013.<br>CANADA IC RSS-139 Issue 3. Jul. 2015.<br>ANSI C63.26 – 2015 |
| Summary | IN COMPLIANCE |
| Approved by (name / position & signature) | A. Llamas<br>RF Lab. Manager<br>Firmado digitalmente por ALEJANDRO LLAMAS RODRIGUEZ<br>Fecha: 2019.06.04 08:38:49 +02'00' |
| Date of issue | 2019-06-03 |
| Report template No | FDT08_20 |

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# Competences and guarantees

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

DEKRA Testing and Certification is a laboratory with a measurement facility in compliance with the requirements of Section 2.948 of the FCC rules and has been added to the list of facilities whose measurements data will be accepted in conjuction with applications for Certification under Parts 15 or 18 of the Commission's Rules. Registration Number: 720267.

DEKRA Testing and Certification is a laboratory with a measurement site in compliance with the requirements of RSS 212. Issue 1 (Provisional) and has been added to the list of filed sites of the Canadian Certification and Engineering Bureau. Reference File Number: ISED 4621A-4.

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

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

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

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



# General conditions

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

# Uncertainty

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

# Usage of samples

Samples undergoing test have been selected by: the client.

Sample S/01 is composed of the following elements:

| Control Nº | Description | Model | Serial Nº | Date of reception |
|---|---|---|---|---|
| 59678C/004 | IOT Module | nRF9160 | IMEI: 352656100030561 | 2019-01-15 |

1. Sample S/01 has undergone the following test(s):

All tests indicated in appendixes A and B.

# Data provided by the client

The sample consist of a IOT Module that has Application CPU. LTE Cat-M1. Cat-NB1 Radio and GPS Receiver.

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

# Test sample description

<table>
<tr><td rowspan="5">Ports…… :</td><td rowspan="2">Port name and description</td><td colspan="3">Cable</td></tr>
<tr><td>Specified length [m]</td><td>Attached during test</td><td>Shielded</td></tr>
<tr><td>LTE RF</td><td>2</td><td>☒</td><td>☒</td></tr>
<tr><td>GPS</td><td>2</td><td>☒</td><td>☒</td></tr>
<tr><td></td><td></td><td>☐</td><td>☐</td></tr>
<tr><td></td><td></td><td>☐</td><td>☐</td></tr>
<tr><td>Supplementary information to the ports…… :</td><td colspan="4">N/A</td></tr>
<tr><td rowspan="4">Rated power supply ..... :</td><td colspan="2" rowspan="2">Voltage and Frequency</td><td colspan="3">Reference poles</td></tr>
<tr><td>L1</td><td>L2</td><td>L3</td><td>N</td><td>PE</td></tr>
<tr><td>☐</td><td>AC:</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td></tr>
<tr><td>☒</td><td colspan="5">DC: 3.1 – 5.5Vdc.</td></tr>
<tr><td>☐</td><td colspan="5">DC:</td></tr>
<tr><td>Rated Power ..... :</td><td colspan="4">1W</td></tr>
<tr><td>Clock frequencies ..... :</td><td colspan="4">32kHz. 32MHz</td></tr>
</table>

| | | | | |
|---|---|---|---|---|
| Other parameters.....: | --- | | | |
| Software version .....: | mfw_nrf9160_0.7.0-29.alpha | | | |
| Hardware version.....: | DEV2.1.6 | | | |
| Dimensions in cm (L x W x D) ....: | 11x16x1.1mm | | | |
| Mounting position.....: | ☐ | Table top equipment | | |
| | ☐ | Wall/Ceiling mounted equipment | | |
| | ☐ | Floor standing equipment | | |
| | ☐ | Hand-held equipment | | |
| | ☒ | Other: SMD Module | | |
| Modules/parts .....: | Module/parts of test item | | Type | Manufacturer |
| | N/A | | | |
| Accessories (not part of the test item) .....: | Description | | Type | Manufacturer |
| | N/A | | | |
| | N/A | | | |
| | N/A | | | |
| Documents as provided by the applicant.....: | Description | | File name | Issue date |
| | User manual | | 4418_1177-0.3.1-20180905-140910-nRF9160_Objective_Product_Spec | 23-Oct-2018 |
| | Cover markings | | SiP marking | 23-Oct-2018 |
| | | | | |

**Copy of marking plate:**

# 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)** | 2018-01-30 |
| **Date (finish)** | 2018-04-25 |

# Document history

| Report number | Date | Description |
|---|---|---|
| 59675RRF.002 | 2019-06-03 | First release |
| | | |
| | | |

# 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. = 35 % |

# Remarks and comments

The tests have been performed by the technical personnel: José Alberto Aranda.

Used instrumentation:

Conducted Measurements

| | | Last Cal. date | Cal. due date |
|---|---|---|---|
| 1. | Spectrum analyser Agilent E4440A | 2017/10 | 2019/10 |
| 2. | Vector signal analyzer Rohde & Schwarz FSQ8 | 2018/08 | 2020/08 |
| 3. | Climatic chamber HERAEUS VM 04/35 | 2018/06 | 2020/06 |
| 4. | DC power supply R&S NGPE 40/40 | 2018/02 | 2021/02 |
| 5. | Universal Radio communication Tester R&S CMW50 | 2019/02 | 2020/02 |
| 6. | Spectrum analyser Rohde & Schwarz FSV40 | 2017/07 | 2019/07 |

Radiated Measurements

| | | Last Cal. date | Cal. due date |
|---|---|---|---|
| 1. | Semianechoic Absorber Lined Chamber ETS FACT3 200STP | N.A. | N.A. |
| 2. | BiconicalLog antenna ETS LINDGREN 3142E | 2017/09 | 2020/09 |
| 3. | Multi Device Controller MESSTECHNIK DAV-RR | N.A. | N.A. |
| 4. | Double-ridge Guide Horn antenna 1-18 GHz SCHWARZBECK BBHA 9120 D | 2018/01 | 2021/01 |
| 5. | Broadband Horn antenna 18-40 GHz SCHWARZBECK BBHA 9170 | 2018/07 | 2021/07 |
| 6. | Spectrum analyser Rohde & Schwarz FSV40 | 2018/02 | 2020/02 |
| 7. | EMI Test Receiver R&S ESU26 | 2018/02 | 2020/02 |
| 8. | RF pre-amplifier 1-18 GHz Bonn Elektronik BLMA 0118-3A | 2019/04 | 2020/04 |
| 9. | RF pre-amplifier 18-40 GHz NARDA JS44-18004000-33-8P | 2019/02 | 2020/02 |
| 10. | RF pre-amplifier 30-6 GHz Bonn Elektronik BLMA 0160-01N | 2019/02 | 2020/08 |

# Testing verdicts

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

# Summary

| FCC PART 24/IC RSS-133 PARAGRAPH<br>Requirement – Test case | Verdict | Remark |
|---|---|---|
| Clause 24.232/RSS-133 Clause 6.4: RF output power | P | |
| Clause 2.1047/RSS-133 Clause 6.2: Modulation characteristics | P | |
| Clause 24.235/RSS-133 Clause 6.3: Frequency stability | P | |
| Clause 2.1049: Occupied Bandwidth | P | |
| Clause 24.238/RSS-133 Clause 6.5: Spurious emissions at antenna terminals | P | |
| Clause 24.238/RSS-133 Clause 6.5: Radiated emissions | P | |
| Supplementary information and remarks:<br>None | | |

| FCC PART 27 / RSS-139 / RSS-130 PARAGRAPH<br>Requirement – Test case | Verdict | Remark |
|---|---|---|
| Clause 27.50 / RSS-139 Clause 6.5. / RSS-130 Clause 4.4.: RF output power | P | |
| Clause 2.1047 / RSS-139 Clause 6.2. / RSS-130 Clause 4.1.: Modulation characteristics | P | |
| Clause 27.54 / RSS-139 Clause 6.4. / RSS-130 Clause 4.3.: Frequency stability | P | |
| Clause 2.1049: Occupied Bandwidth | P | |
| Clause 27.53 / RSS-139 Clause 6.6. / RSS-130 Clause 4.6.: Spurious emissions at antenna terminals | P | |
| Clause 27.53 / RSS-139 Clause 6.6. / RSS-130 Clause 4.6.: Radiated emissions | P | |
| Supplementary information and remarks:<br>None. | | |

# **Appendix A:** Test results for FCC Part 24 / RSS-133

# INDEX

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# TEST CONDITIONS

Power supply (V):

Vnominal = 3.8 Vdc

Vmax = 4.37 Vdc

Vmin = 3.23 Vdc

The subscripts nom. min and max indicate voltage test conditions (nominal. minimum and maximum respectively. as declared by the applicant).

Type of power supply = DC Voltage from external power supply

Type of antenna = Integral antenna.

Declared Gain for antenna = +4.4 dBi.

TEST FREQUENCIES:

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 2)

| Channel (Frequency. MHz) | | |
|---|---|---|
| Lowest | Middle | Highest |
| 18602 (1850.2) | 18900 (1880) | 19198 (1909.8) |

NOTE: Band 2 is completely included in band 25. so the channels of band 25 were tested to give conformity to the assigned block.

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 25)

| Channel (Frequency. MHz) | | |
|---|---|---|
| Lowest | Middle | Highest |
| 26042 (1850.2) | 26365 (1882.5) | 26688 (1914.8) |

# RF Output Power

## SPECIFICATION

FCC §2.1046 and §24.232

Mobile/portable stations are limited to 2 Watts (33 dBm) Effective Isotropic Radiated Power (E.I.R.P.).
The peak-to-average ratio (PAR) of the transmission shall not exceed 13 dB.

RSS-133. Clause 6.4.

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

## 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).

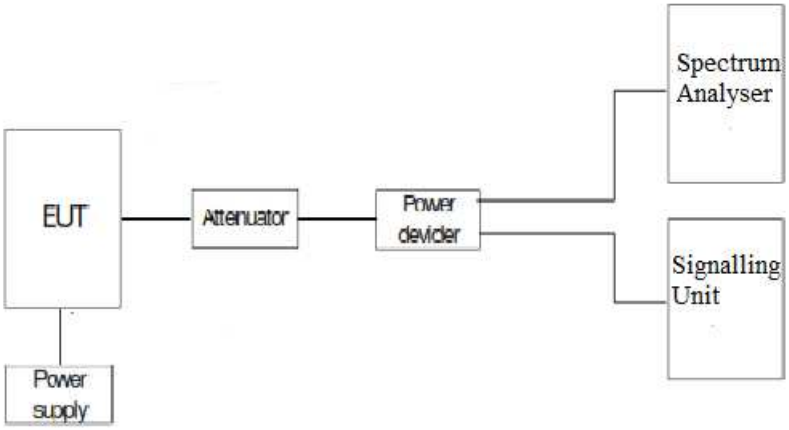
The peak-to-average power ratio (PAPR) is measured using an attenuator. power splitter and spectrum analyser with a Complementary Cumulative Distribution Function implemented.

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

Conducted average power.


Peak-to-average power ratio (PAPR)



RESULTS

MAXIMUM OUTPUT POWER (CONDUCTED).

NBIoT. BAND 25.

| Ch | Freq. (MHz) | Modulation | BW (kHz) | Num. tone | Offset Tone | Average Power (dBm) | PAPR (dB) |
|---|---|---|---|---|---|---|---|
| 26042 | 1850.2 | π/2 - BPSK | 3.75 | 1 | 0 | 23.02 | (*) |
| | | | | 1 | 47 | 22.96 | (*) |
| | | | 15 | 1 | 0 | 22.97 | (*) |
| | | | | 1 | 11 | 22.95 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.98 | (*) |
| | | | | 1 | 47 | 22.91 | (*) |
| | | | 15 | 1 | 0 | 23.05 | (*) |
| | | | | 1 | 11 | 22.96 | (*) |
| | | | | 3 | 0 | 22.96 | 3.43 |
| | | | | 3 | 6 | 23.31 | 3.21 |
| | | | | 6 | 0 | 22.18 | 4.21 |
| | | | | 6 | 6 | 22.31 | 4.21 |
| | | | | 12 | 0 | 21.28 | 3.81 |
| 26365 | 1882.5 | π/2 - BPSK | 3.75 | 1 | 0 | 22.48 | (*) |
| | | | | 1 | 47 | 22.45 | (*) |
| | | | 15 | 1 | 0 | 22.42 | (*) |
| | | | | 1 | 11 | 22.36 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.45 | (*) |
| | | | | 1 | 47 | 22.44 | (*) |
| | | | 15 | 1 | 0 | 22.4 | (*) |
| | | | | 1 | 11 | 22.25 | (*) |
| | | | | 3 | 0 | 21.3 | 3.22 |
| | | | | 3 | 6 | 21.29 | 4.54 |
| | | | | 6 | 0 | 21.37 | 4.13 |
| | | | | 6 | 6 | 19.91 | 6.62 |
| | | | | 12 | 0 | 19.91 | 4.76 |
| 26688 | 1914.8 | π/2 - BPSK | 3.75 | 1 | 0 | 23.28 | (*) |
| | | | | 1 | 47 | 23.32 | (*) |
| | | | 15 | 1 | 0 | 23.3 | (*) |
| | | | | 1 | 11 | 23.3 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 23.29 | (*) |
| | | | | 1 | 47 | 23.34 | (*) |
| | | | 15 | 1 | 0 | 23.4 | (*) |
| | | | | 1 | 11 | 23.33 | (*) |
| | | | | 3 | 0 | 23.25 | 3.32 |
| | | | | 3 | 6 | 23.89 | 2.98 |
| | | | | 6 | 0 | 22.49 | 3.89 |
| | | | | 6 | 6 | 22.61 | 3.91 |
| | | | | 12 | 0 | 21.51 | 3.88 |

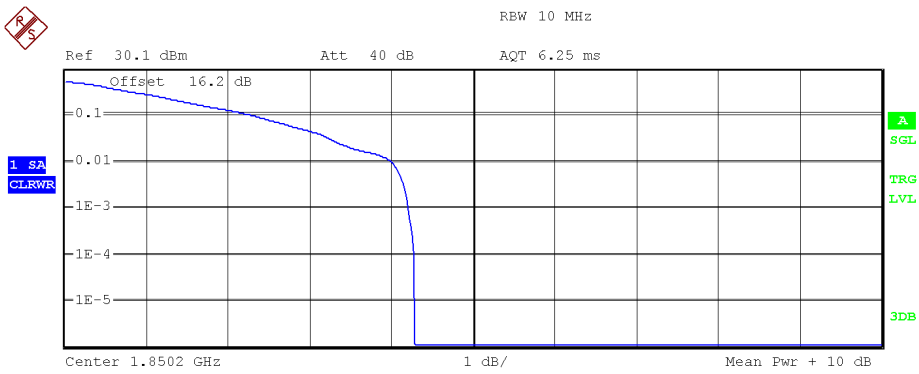
(*): Preliminary measurements determined that 3. 6 or 12 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

PEAK-TO-AVERAGE POWER RATIO (PAPR).

NBIoT. BAND 25.

Preliminary measurements determined that 6 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

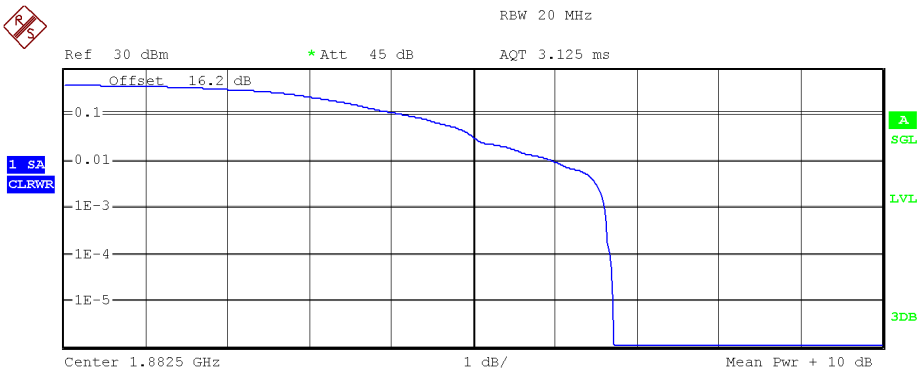
Channel Low:




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

| | Trace 1 |
|---|---|
| Mean | 22.02 dBm |
| Peak | 26.31 dBm |
| Crest | 4.28 dB |
| 10 % | 2.29 dB |
| 1 % | 4.01 dB |
| .1 % | 4.21 dB |
| .01 % | 4.28 dB |

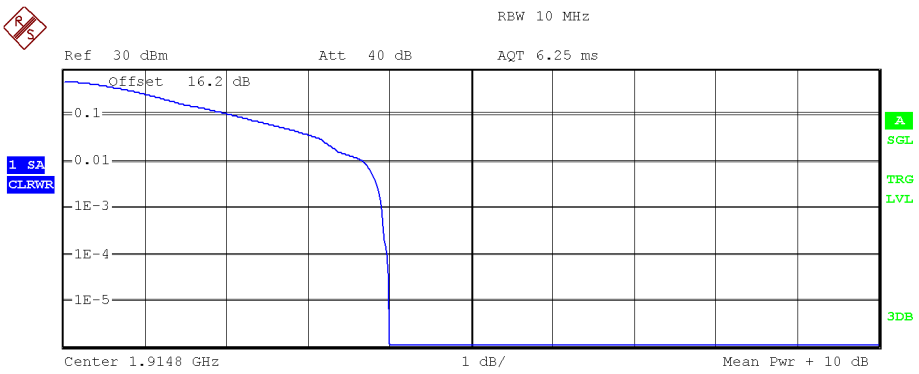
Channel Middle:




**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 23.7MHz**

| | Trace 1 |
|---|---|
| Mean | 19.27 dBm |
| Peak | 25.98 dBm |
| Crest | 6.71 dB |
| 10 % | 4.17 dB |
| 1 % | 5.99 dB |
| .1 % | 6.62 dB |
| .01 % | 6.68 dB |

Channel High:




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

| | Trace 1 |
|---|---|
| Mean | 22.01 dBm |
| Peak | 26.00 dBm |
| Crest | 4.00 dB |
| 10 % | 2.08 dB |
| 1 % | 3.69 dB |
| .1 % | 3.91 dB |
| .01 % | 3.97 dB |

NBIoT BAND 25.

| Channel | Measured maximum average power (dBm) at antenna port | Maximum declared antenna gain (dBi) | Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm) | Maximum effective radiated power E.R.P. (dBm) | PAPR (dB) |
|---|---|---|---|---|---|
| Lowest | 23.31 | +4.4 | 27.71 | 25.56 | 4.21 |
| Middle | 22.48 | +4.4 | 26.88 | 24.73 | 6.62 |
| Highest | 23.89 | +4.4 | 28.29 | 26.14 | 3.91 |
| Measurement uncertainty (dB) | <±1.11 | | | | |

Verdict: PASS

# Frequency Stability

## SPECIFICATION

FCC §2.1055 and §24.235. The frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block.

RSS-133. Clause 6.3. The carrier frequency shall not depart from the reference frequency in excess of ±2.5 ppm for mobile stations.

## 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.

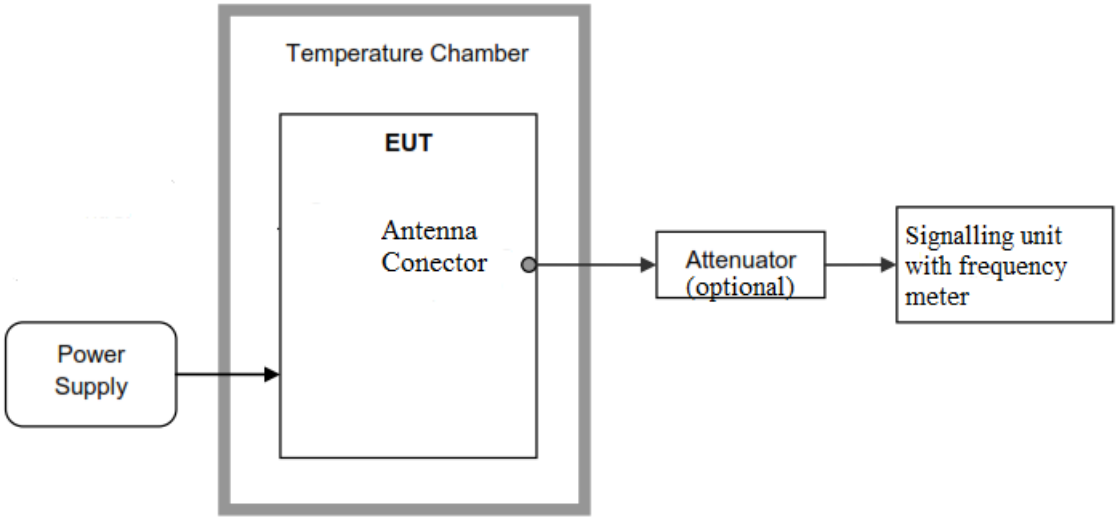
The EUT was set in “Radio Resource Control (RRC) mode” in the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case NBIoT mode for conducted power was used for the test.

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.

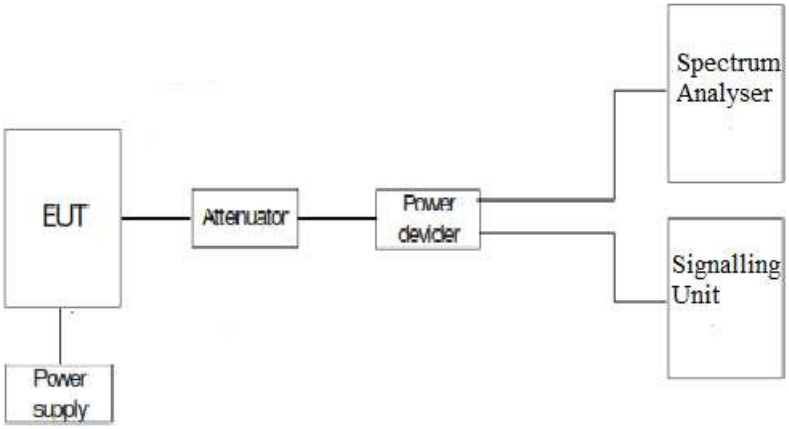
The reference point measurements were made at the RF output terminals of the EUT using an attenuator. power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

TEST SETUP

Frequency tolerance.




Reference points *f*L and *fH.*



RESULTS

Frequency stability over temperature variations.

NBIoT Band 25

| Temperature (ºC) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|
| +50 | 5.25 | 0.002788845 |
| +40 | -25.13 | -0.01334927 |
| +30 | 45.09 | 0.023952191 |
| +20 | 8.96 | 0.004759628 |
| +10 | -14.96 | -0.007946879 |
| 0 | 11.69 | 0.006209827 |
| -10 | 14.16 | 0.007521912 |
| -20 | 5.98 | 0.003176627 |
| -30 | 43.3 | 0.023001328 |

Frequency stability over voltage variations.

NBIoT Band 25

| Battery Supply voltage | Voltage (V) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|---|
| Vmax | 4.37 | -3.35 | -0.001779548 |
| Vmin | 3.23 | -5.18 | -0.00275166 |

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

| | NBIoT Band 25 |
|---|---|
| *f*L (MHz) | 1850.0410 |
| *fH (MHz)* | 1914.9630 |

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

| | NBIoT Band 25 |
|---|---|
| *f*L (MHz) | 1850.0410 |
| *fH (MHz)* | 1914.9630 |

The reference frequency points stay within the authorized blocks.

Verdict: PASS

# Modulation Characteristics

## SPECIFICATION

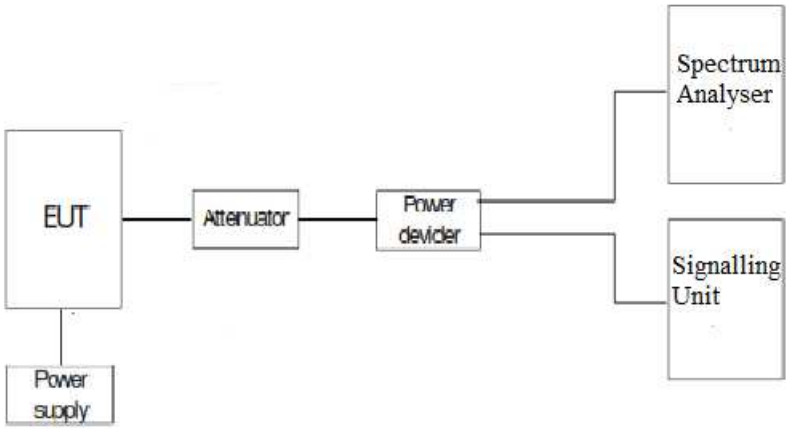
FCC §2.1047

RSS-133. Clause 6.2. Equipment certified under this standard shall use digital modulation.

## METHOD

For NBIoT the EUT operates with π/2 - BPSK and π/4 - QPSK modulation modes in which the information is digitised and coded into a bit stream.

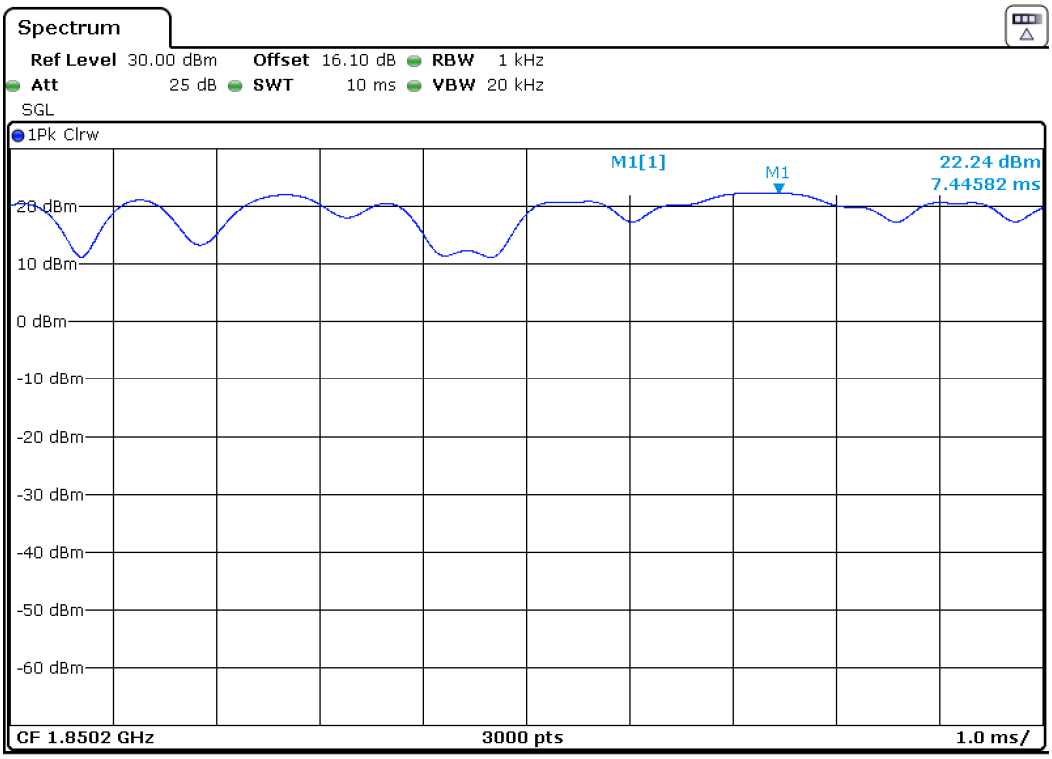
## TEST SETUP



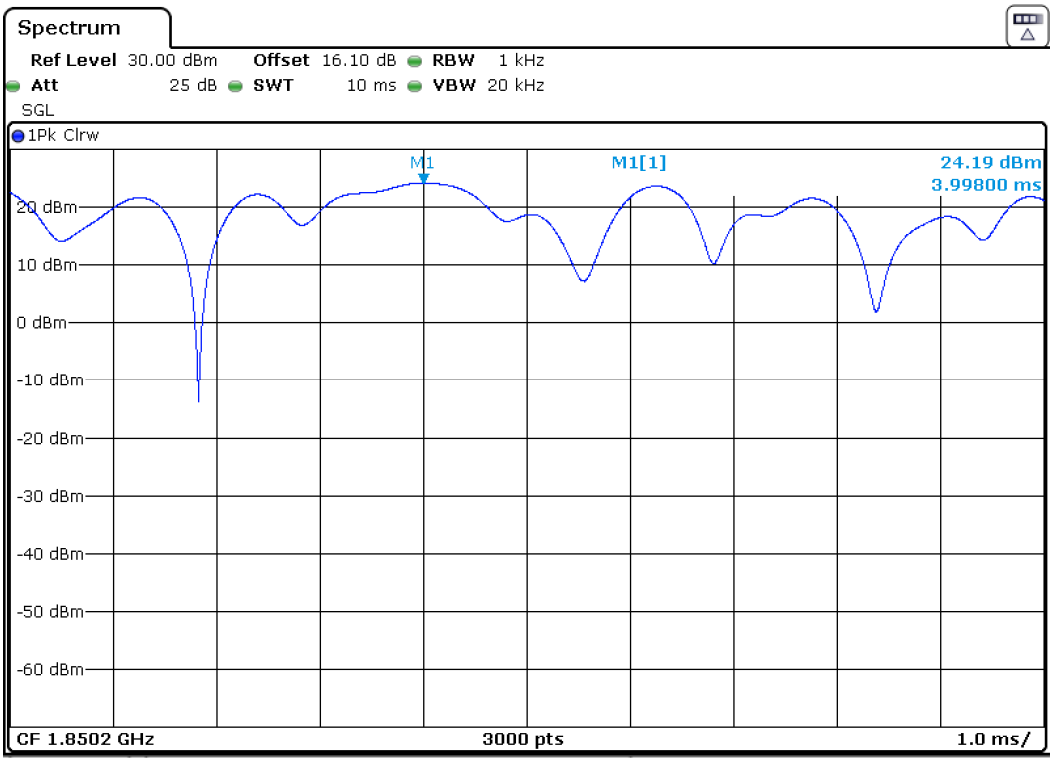

## RESULTS

The following plot shows the modulation schemes in the EUT.

NBIoT MODULATION (Band 25). π/2 - BPSK.




NBIoT MODULATION (Band 25). π/4 - QPSK.



# Occupied Bandwidth

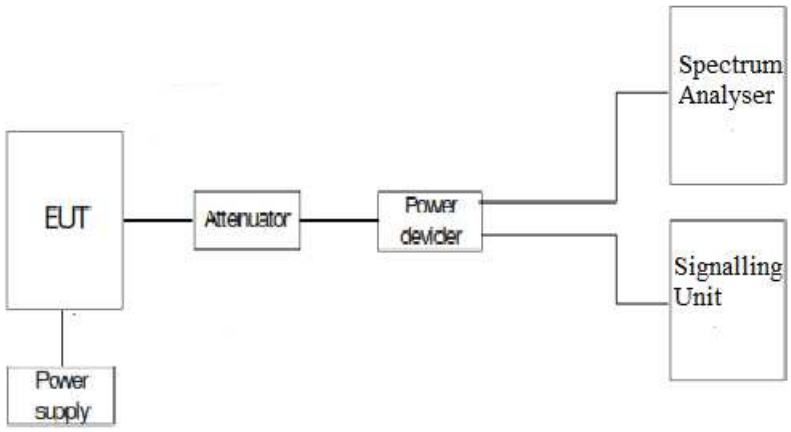
## SPECIFICATION

§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)

NBIoT BAND 25.

Tone 3.75 kHz. π/2 - BPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 58.800 | 60.000 | 59.600 |
| -26 dBc bandwidth (kHz) | 41.267 | 41.467 | 41.267 |
| Measurement uncertainty (kHz) | <±0.05 | | |

Tone 3.75 kHz. π/4 - QPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 63.130 | 63.460 | 63.800 |
| -26 dBc bandwidth (kHz) | 41.933 | 42.000 | 41.867 |
| Measurement uncertainty (kHz) | <±0.05 | | |

Tone 15 kHz. π/2 - BPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 140.40000 | 140.80000 | 141.73000 |
| -26 dBc bandwidth (kHz) | 128.13000 | 128.80000 | 128.27000 |
| Measurement uncertainty (kHz) | <±0.10 | | |

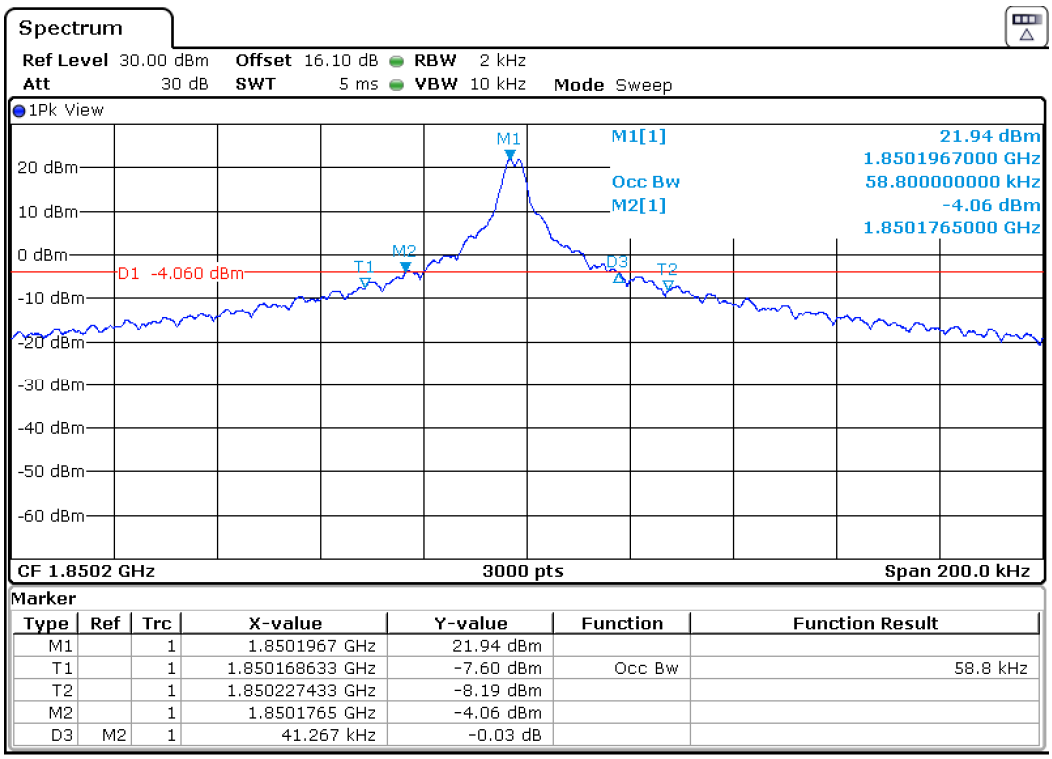
12 Tones 15 kHz. π/4 - QPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 200.130 | 204.000 | 204.660 |
| -26 dBc bandwidth (kHz) | 322.800 | 322.800 | 311.470 |
| Measurement uncertainty (kHz) | <±0.12 | | |

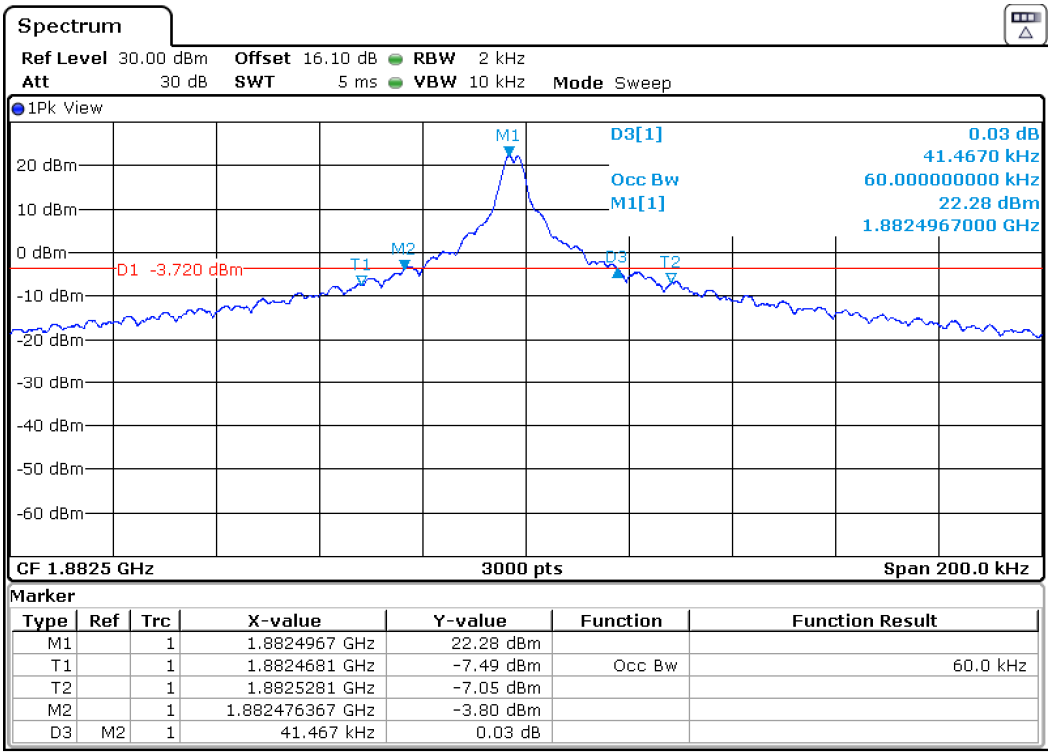
NBIoT BAND 25.

Tone 3.75 kHz. π/2 - BPSK MODULATION

Lowest Channel



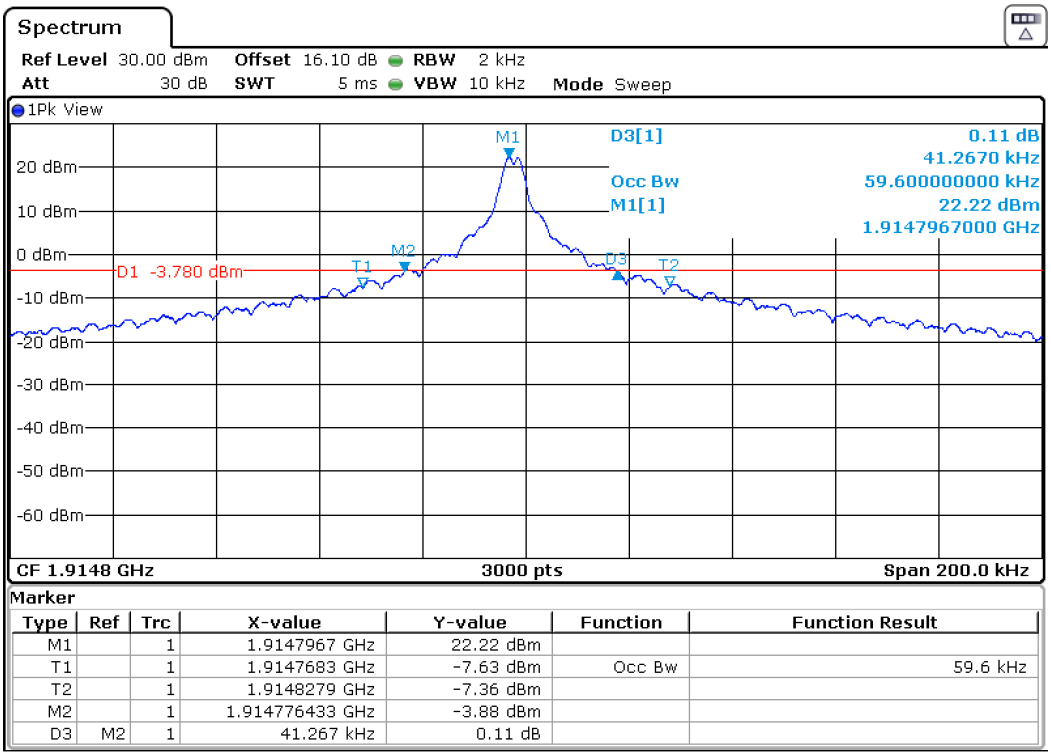
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.8824967 GHz | 22.28 dBm | | |
| T1 | | 1 | 1.8824681 GHz | -7.49 dBm | Occ Bw | 60.0 kHz |
| T2 | | 1 | 1.8825281 GHz | -7.05 dBm | | |
| M2 | | 1 | 1.882476367 GHz | -3.80 dBm | | |
| D3 | M2 | 1 | 41.467 kHz | 0.03 dB | | |

Highest Channel

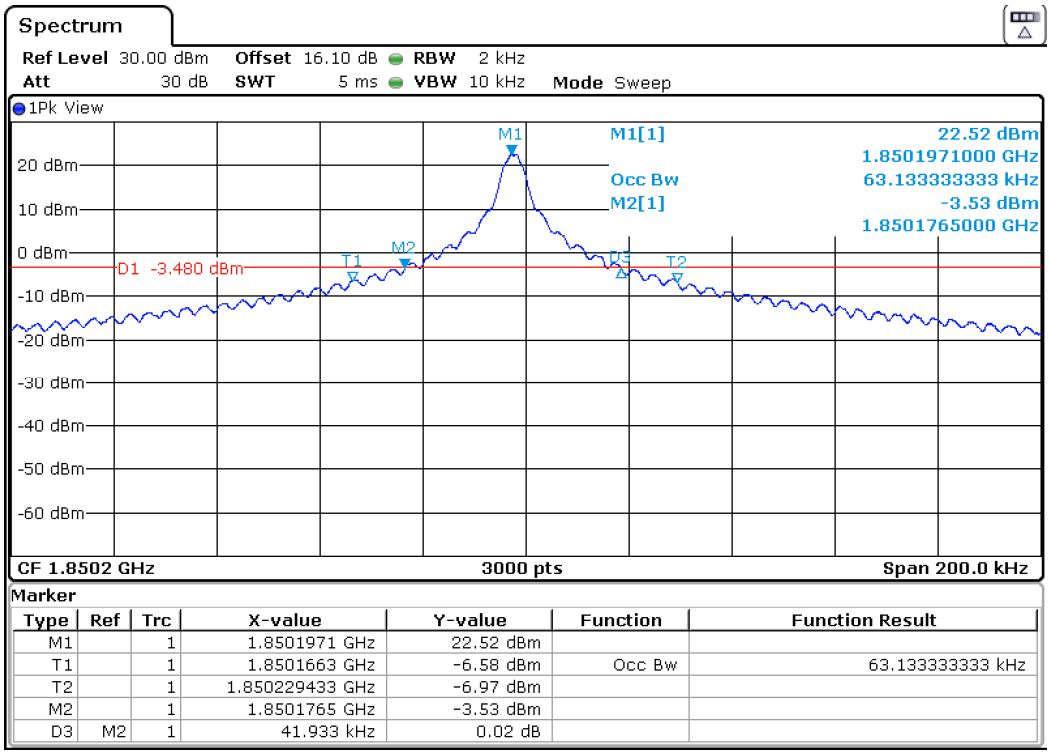



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.9147967 GHz | 22.22 dBm | | |
| T1 | | 1 | 1.9147683 GHz | -7.63 dBm | Occ Bw | 59.6 kHz |
| T2 | | 1 | 1.9148279 GHz | -7.36 dBm | | |
| M2 | | 1 | 1.914776433 GHz | -3.88 dBm | | |
| D3 | M2 | 1 | 41.267 kHz | 0.11 dB | | |

Tone 3.75 kHz. π/4 - QPSK MODULATION

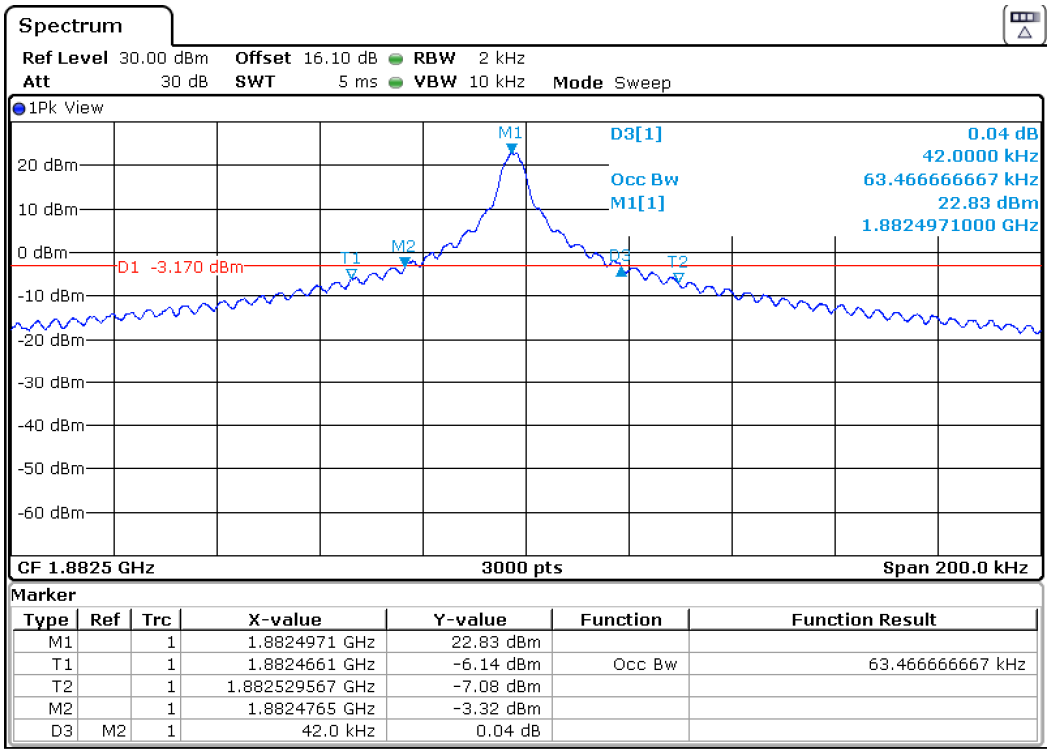
Lowest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.8501971 GHz | 22.52 dBm | | |
| T1 | | 1 | 1.8501663 GHz | -6.58 dBm | Occ Bw | 63.133333333 kHz |
| T2 | | 1 | 1.850229433 GHz | -6.97 dBm | | |
| M2 | | 1 | 1.8501765 GHz | -3.53 dBm | | |
| D3 | M2 | 1 | 41.933 kHz | 0.02 dB | | |

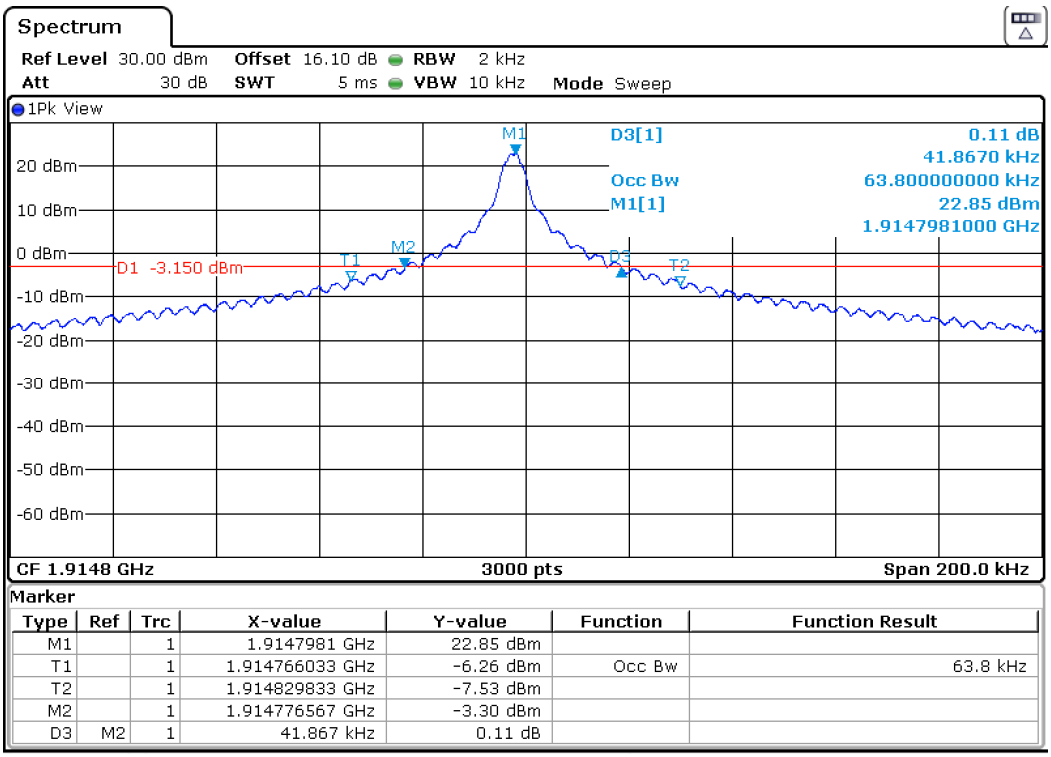
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.8824971 GHz | 22.83 dBm | | |
| T1 | | 1 | 1.8824661 GHz | -6.14 dBm | Occ Bw | 63.466666667 kHz |
| T2 | | 1 | 1.882529567 GHz | -7.08 dBm | | |
| M2 | | 1 | 1.8824765 GHz | -3.32 dBm | | |
| D3 | M2 | 1 | 42.0 kHz | 0.04 dB | | |

Highest Channel

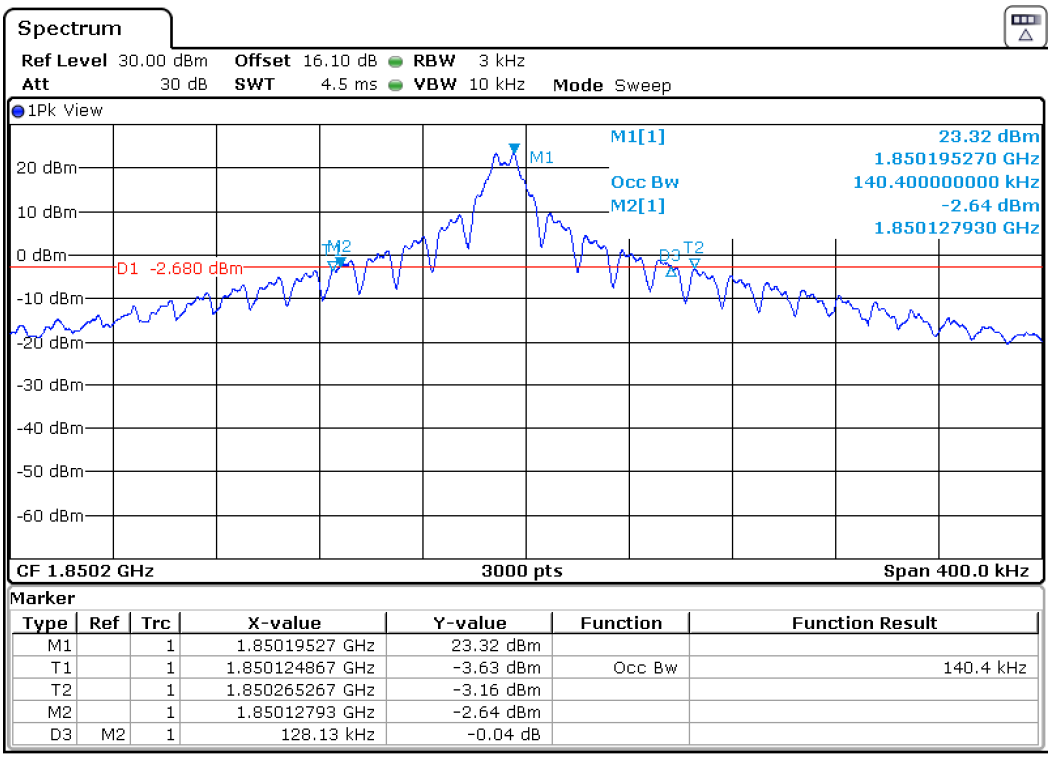



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.9147981 GHz | 22.85 dBm | | |
| T1 | | 1 | 1.914766033 GHz | -6.26 dBm | Occ Bw | 63.8 kHz |
| T2 | | 1 | 1.914829833 GHz | -7.53 dBm | | |
| M2 | | 1 | 1.914776567 GHz | -3.30 dBm | | |
| D3 | M2 | 1 | 41.867 kHz | 0.11 dB | | |

Tone 15 kHz. π/2 - BPSK MODULATION

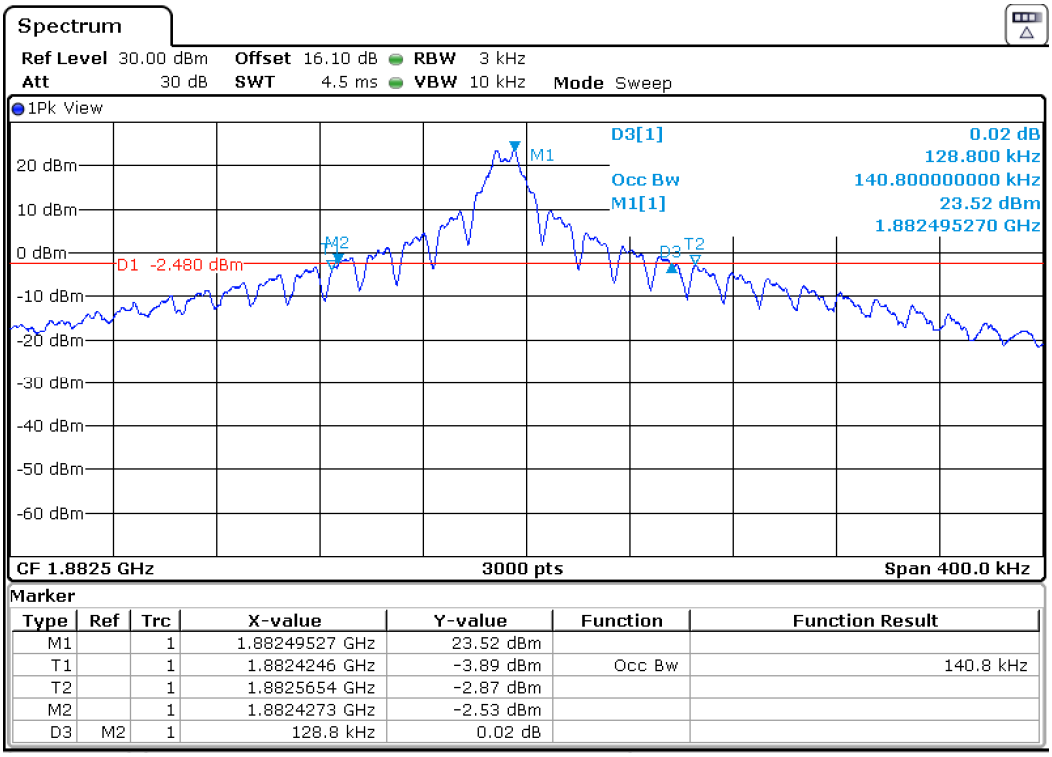
Lowest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.85019527 GHz | 23.32 dBm | | |
| T1 | | 1 | 1.850124867 GHz | -3.63 dBm | Occ Bw | 140.4 kHz |
| T2 | | 1 | 1.850265267 GHz | -3.16 dBm | | |
| M2 | | 1 | 1.85012793 GHz | -2.64 dBm | | |
| D3 | M2 | 1 | 128.13 kHz | -0.04 dB | | |

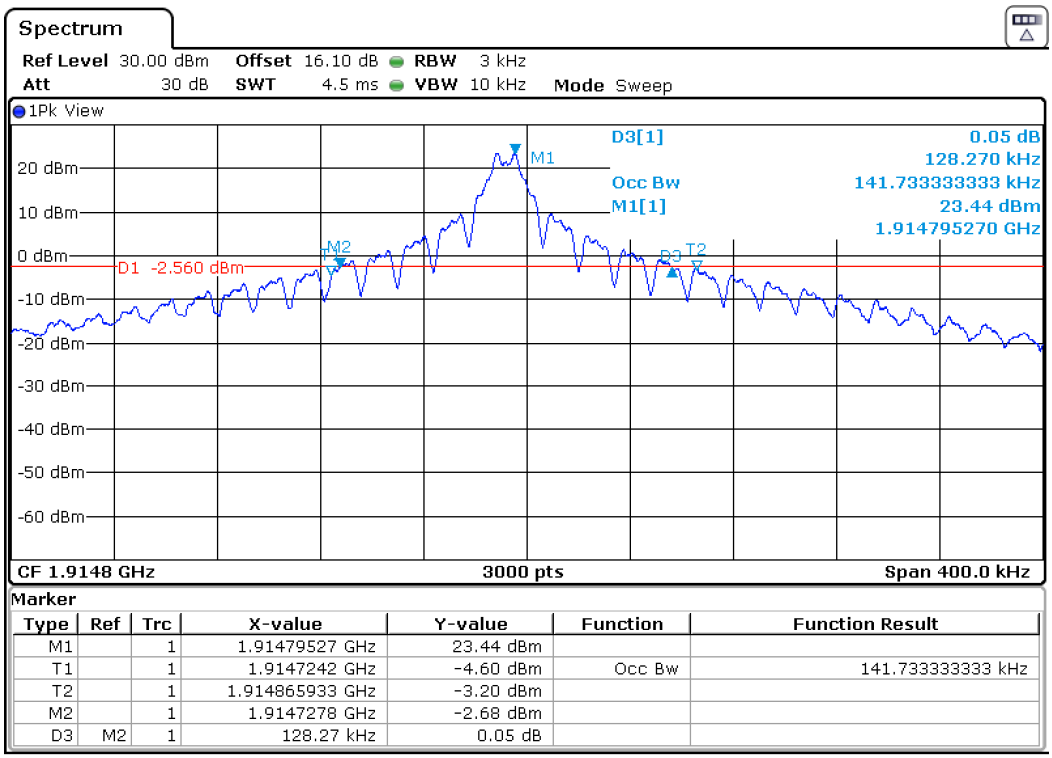
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.88249527 GHz | 23.52 dBm | | |
| T1 | | 1 | 1.8824246 GHz | -3.89 dBm | Occ Bw | 140.8 kHz |
| T2 | | 1 | 1.8825654 GHz | -2.87 dBm | | |
| M2 | | 1 | 1.8824273 GHz | -2.53 dBm | | |
| D3 | M2 | 1 | 128.8 kHz | 0.02 dB | | |

Highest Channel

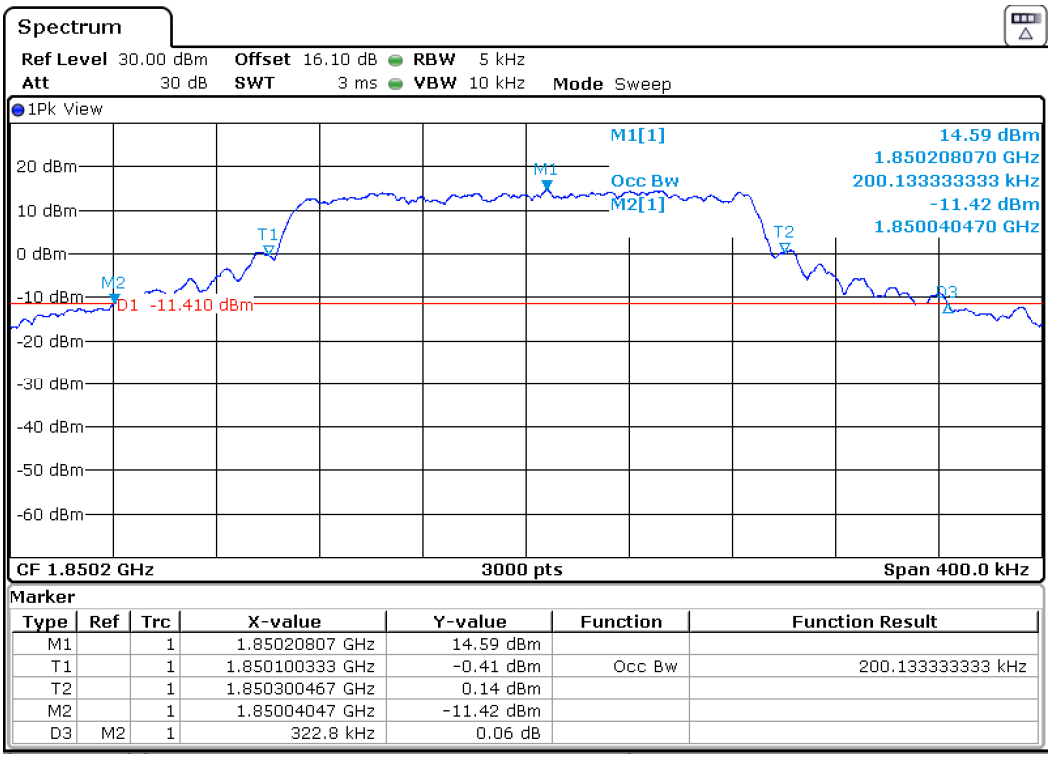



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.91479527 GHz | 23.44 dBm | | |
| T1 | | 1 | 1.9147242 GHz | -4.60 dBm | Occ Bw | 141.733333333 kHz |
| T2 | | 1 | 1.914865933 GHz | -3.20 dBm | | |
| M2 | | 1 | 1.9147278 GHz | -2.68 dBm | | |
| D3 | M2 | 1 | 128.27 kHz | 0.05 dB | | |

12 Tones 15 kHz. π/4 - QPSK MODULATION

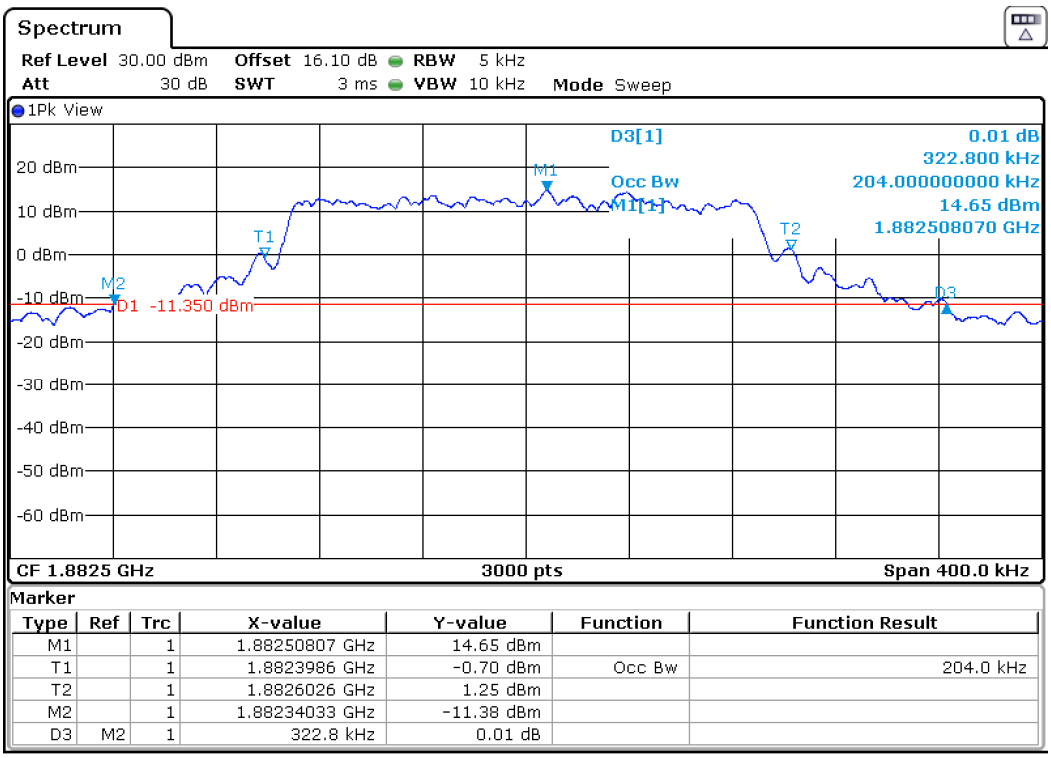
Lowest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.85020807 GHz | 14.59 dBm | | |
| T1 | | 1 | 1.850100333 GHz | -0.41 dBm | Occ Bw | 200.133333333 kHz |
| T2 | | 1 | 1.850300467 GHz | 0.14 dBm | | |
| M2 | | 1 | 1.85004047 GHz | -11.42 dBm | | |
| D3 | M2 | 1 | 322.8 kHz | 0.06 dB | | |

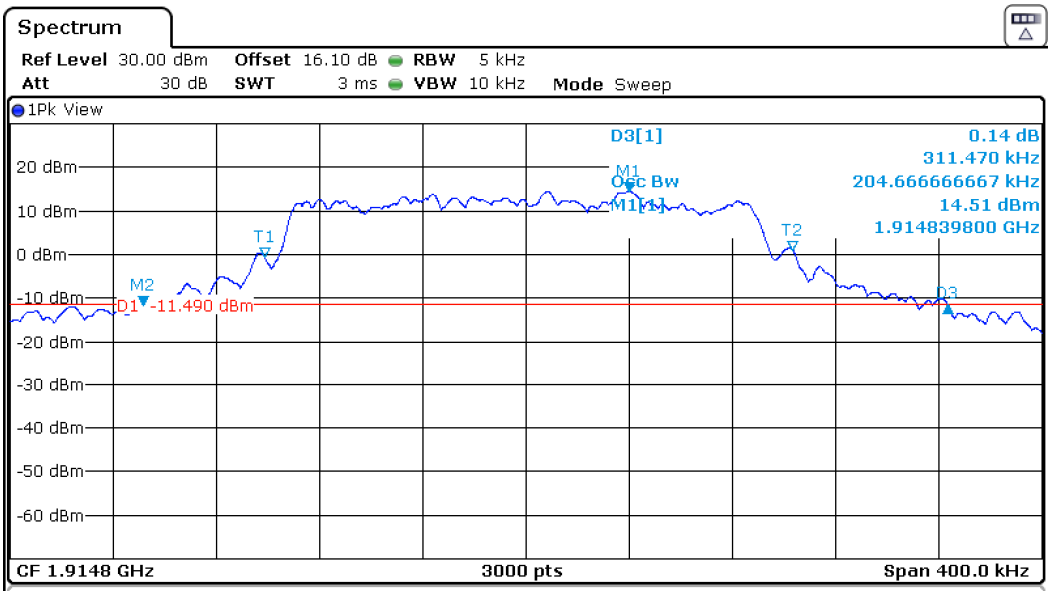
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.88250807 GHz | 14.65 dBm | | |
| T1 | | 1 | 1.8823986 GHz | -0.70 dBm | Occ Bw | 204.0 kHz |
| T2 | | 1 | 1.8826026 GHz | 1.25 dBm | | |
| M2 | | 1 | 1.88234033 GHz | -11.38 dBm | | |
| D3 | M2 | 1 | 322.8 kHz | 0.01 dB | | |

Highest Channel



# Spurious emissions at antenna terminals

## SPECIFICATION

FCC §2.1051 and §24.238. RSS-133. Clause 6.5.

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

At Po transmitting power. the specified minimum attenuation becomes 43+10 log (Po). and the level in dBm relative Po becomes:
Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = -13 dBm.

## METHOD

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

The spectrum was investigated from 9 kHz to 20 GHz for NBIoT Band 25.

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.

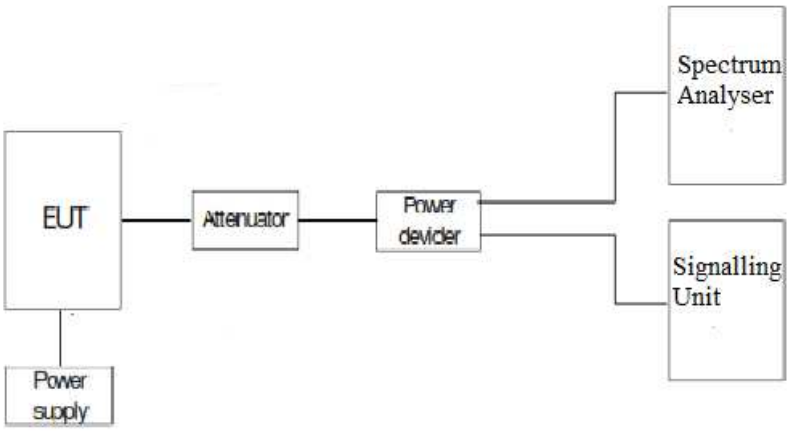
The configuration of Resource Blocks and modulation which is the worst case for conducted power was used.

Measurement Limit:

According to specification. the power of emissions shall be attenuated below the transmitter power (P) by a factor of at least 43 + 10 log (P) dB. P in watts.
At Po transmitting power. the specified minimum attenuation becomes 43+10log (Po). and the level in dBm relative Po becomes:

Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = - 13 dBm

## TEST SETUP



RESULTS (see plots in next pages)

NBIoT Band 25

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

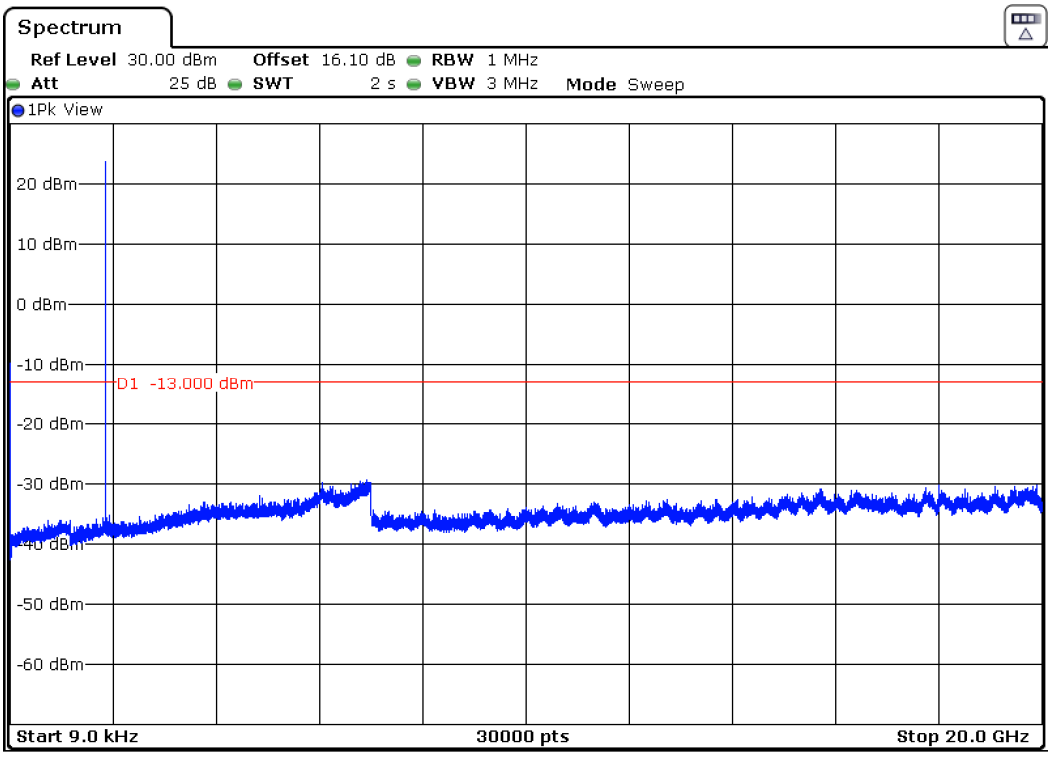
2. CHANNEL: MIDDLE
No spurious signals were found at less than 20dB respect to the limit in all the range.

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

Verdict: PASS

1. CHANNEL: LOWEST

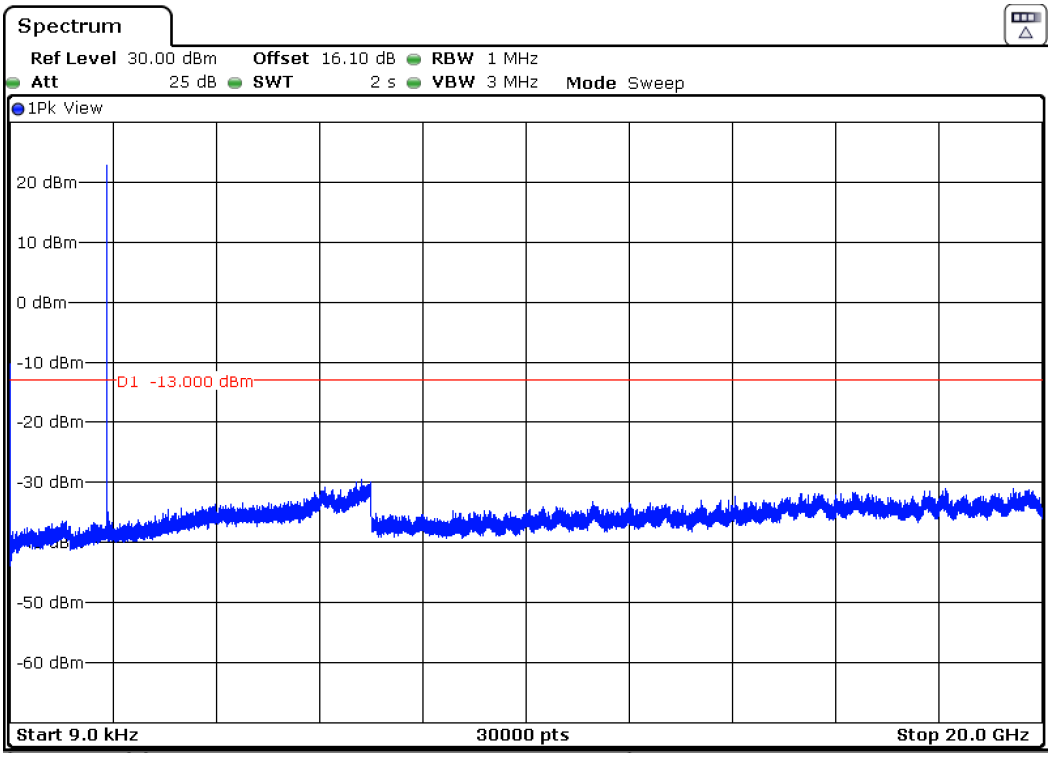
Frequency Range 9 kHz – 20 GHz




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

2. CHANNEL: MIDDLE

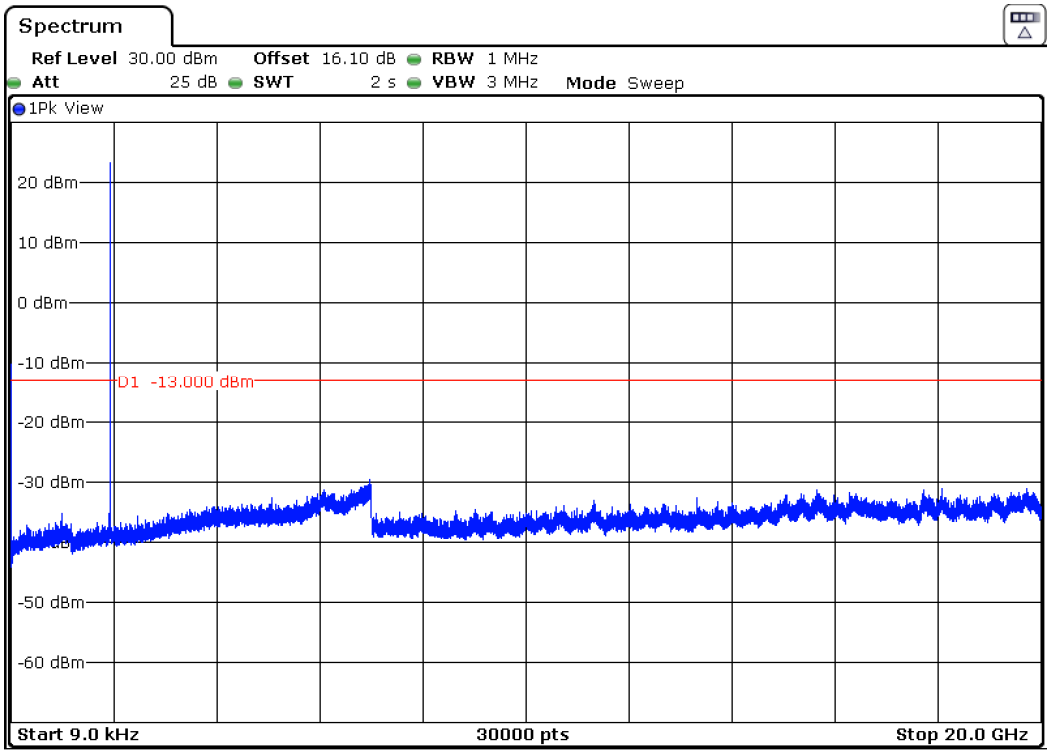
Frequency Range 9 kHz – 20 GHz




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

3. CHANNEL: HIGHEST

Frequency Range 9 kHz – 20 GHz




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

## Spurious emissions at antenna terminals at Block Edges

### SPECIFICATION

FCC §2.1051 and §24.238. RSS-133 Clause 6.5.

### METHOD

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

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

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

As indicated in FCC part 24. in the 1 MHz bands immediately outside and adjacent to the licensee's frequency block. a resolution bandwidth of at least one percent of the emission bandwidth/occupied bandwidth of the fundamental emission of the transmitter may be employed.

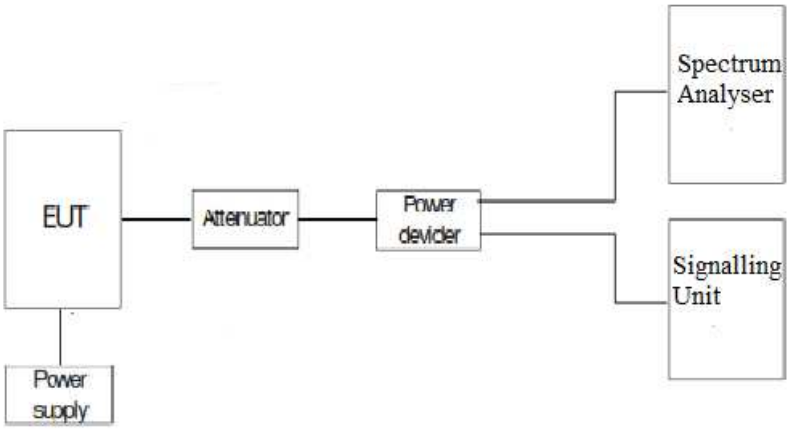
Measurement Limit:

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

At Po transmitting power. the specified minimum attenuation becomes 43+10log (Po). and the level in dBm relative Po becomes:

Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = - 13 dBm

### TEST SETUP



RESULTS (see plots in next pages)

NBIoT. BAND 25.

Preliminary measurements determined a tone with nominal bandwidth of 15 kHz as the worst case. The results in the next tables shows the results for this configuration.

| (Channels in Band 25): | Tone= 15 kHz.<br>Offset=0.<br>π/2 - BPSK |
|---|---|
| Maximum measured level at lowest Block Edge at antenna port (dBm) | -23.34 |

| (Channels in Band 25): | Tone= 15 kHz.<br>Offset=11.<br>π/2 - BPSK |
|---|---|
| Maximum measured level at highest Block Edge at antenna port (dBm) | -22.83 |

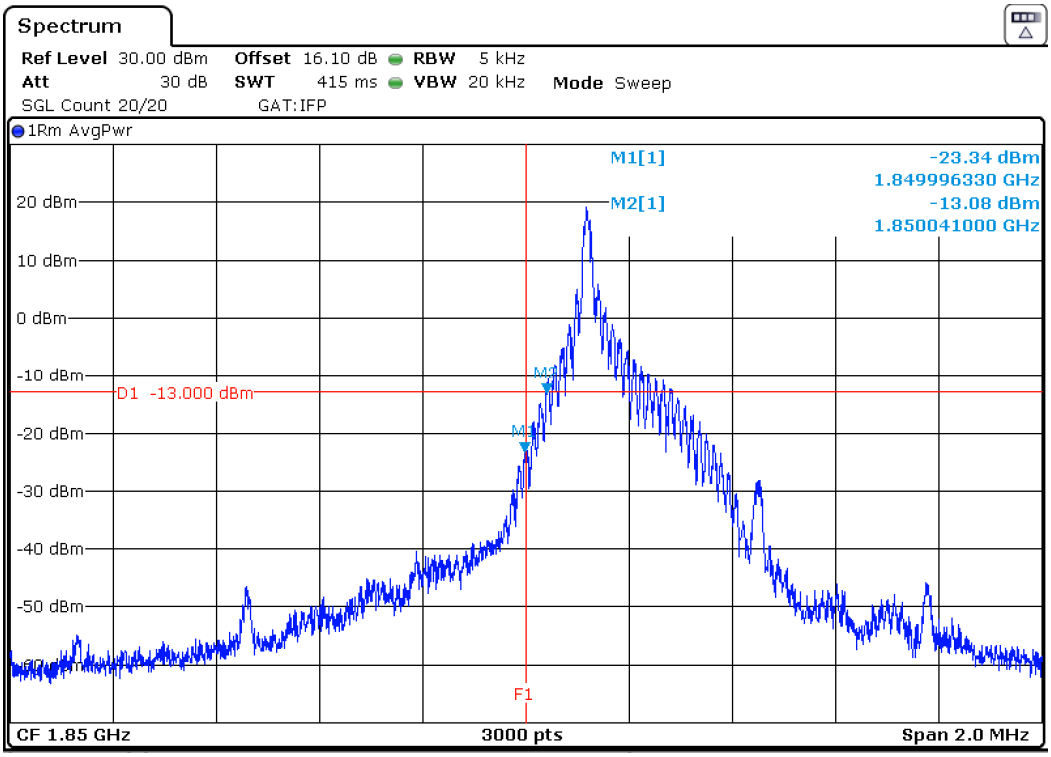
Measurement uncertainty = <±1.20 dB.

Verdict: PASS

NBIoT. BAND 25.

1 tone π/2 – BPSK. BW=15 kHz Offset = 0

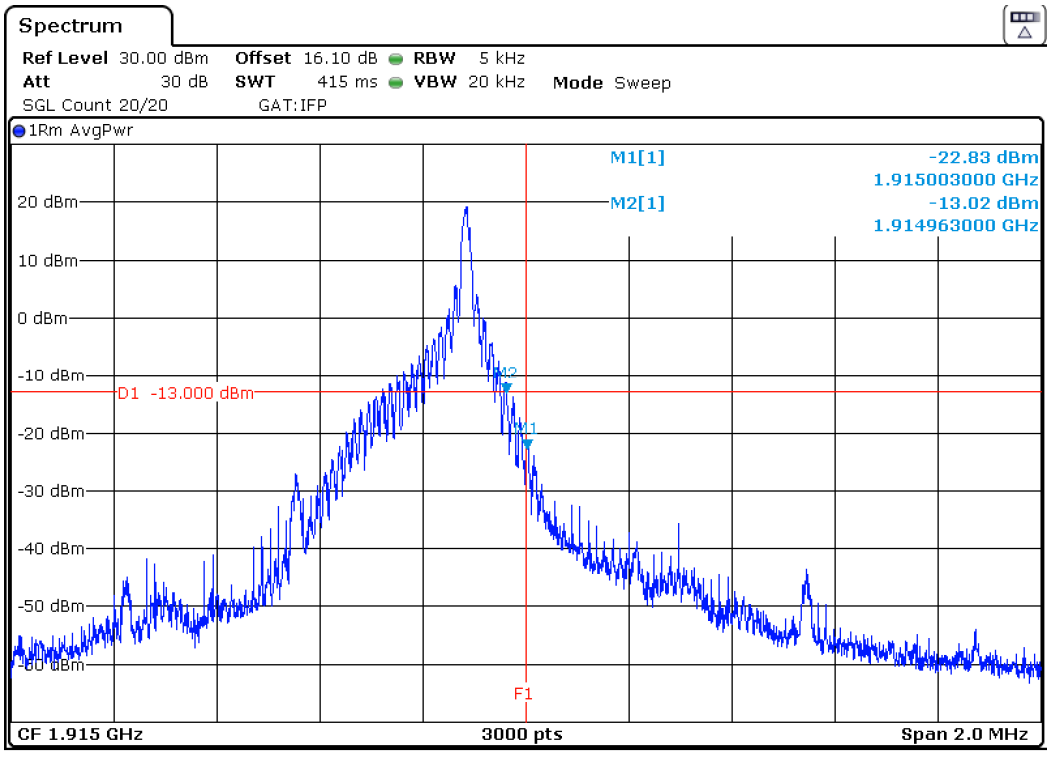
CHANNEL LOWEST




NOTE: The equipment transmits at the maximum output power

1 tone π/2 – BPSK. BW=15 kHz Offset = 11

CHANNEL HIGHEST



# Radiated emissions

## SPECIFICATION

FCC § 24.238. RSS-133 Clause 6.5.

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

## 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 below 1 GHz and at 1 m distance for measurements above 1 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.
Each detected emission at less than 20 dB respect to the limit is substituted by the Substitution method in accordance with the ANSI/TIA-603-E: 2016.

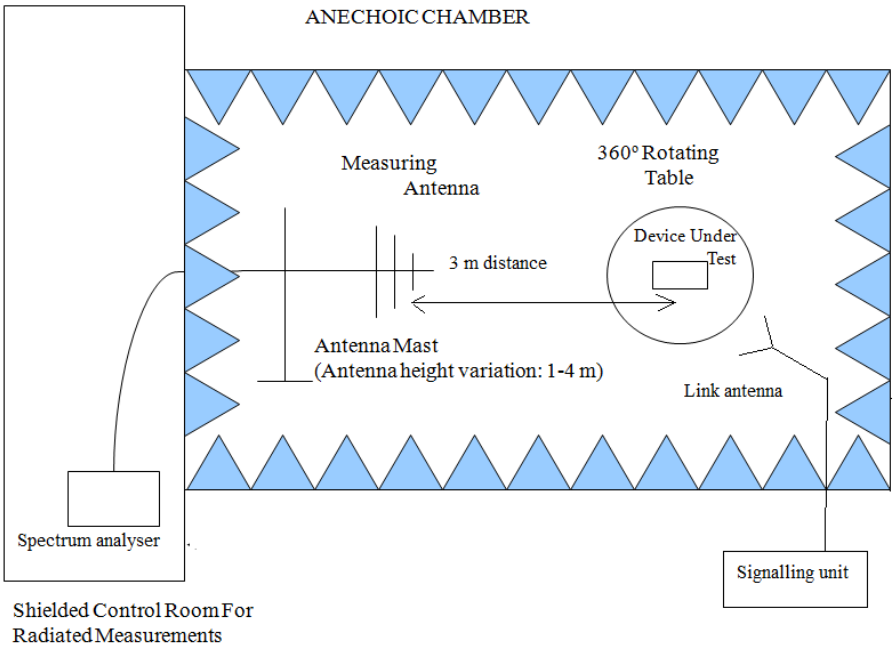
Measurement Limit:

According to specification. the power of emissions shall be attenuated below the transmitter power (P) by a factor of at least 43 + 10 log (P) dB. P in watts.
At Po transmitting power. the specified minimum attenuation becomes 43+10log (Po) and the level in dBm relative Po becomes:

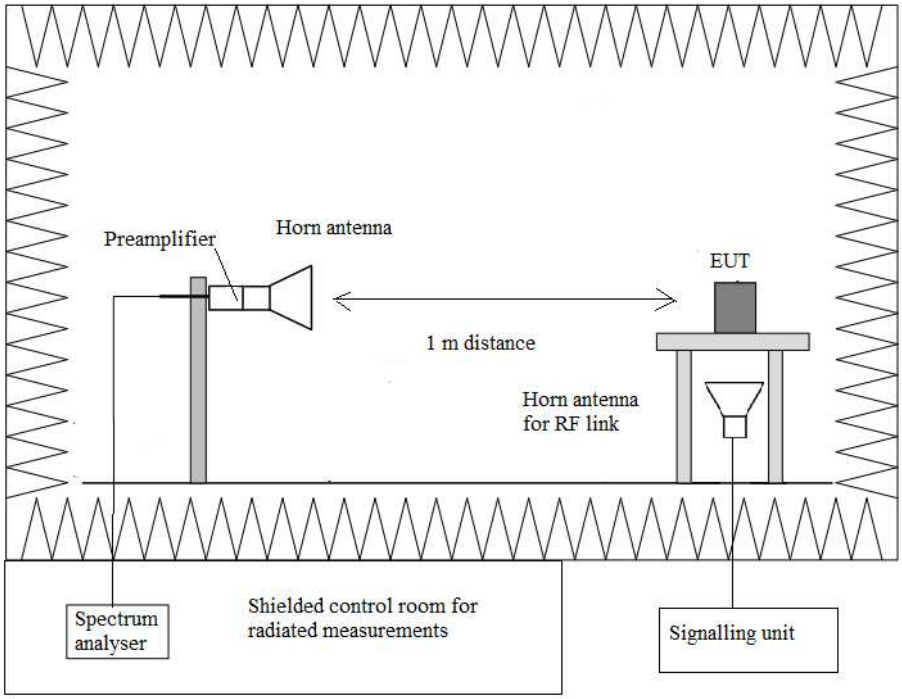
Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = - 13 dBm

## TEST SETUP

Radiated measurements below 1 GHz.




Radiated measurements above 1 GHz.



RESULTS

NBIoT. BAND 25.

Preliminary measurements determined that 3 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

1. CHANNEL: LOWEST
**Frequency range 30 MHz-1000 MHz.**
No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 1 GHz-18 GHz.**
No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 18 GHz-20 GHz.**
No radiated spurious signals were detected at less than 20 dB respect to the limit.

2. CHANNEL: MIDDLE
**Frequency range 30 MHz-1000 MHz**.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 1 GHz-18 GHz**.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 18 GHz-20 GHz.**
No radiated spurious signals were detected at less than 20 dB respect to the limit.

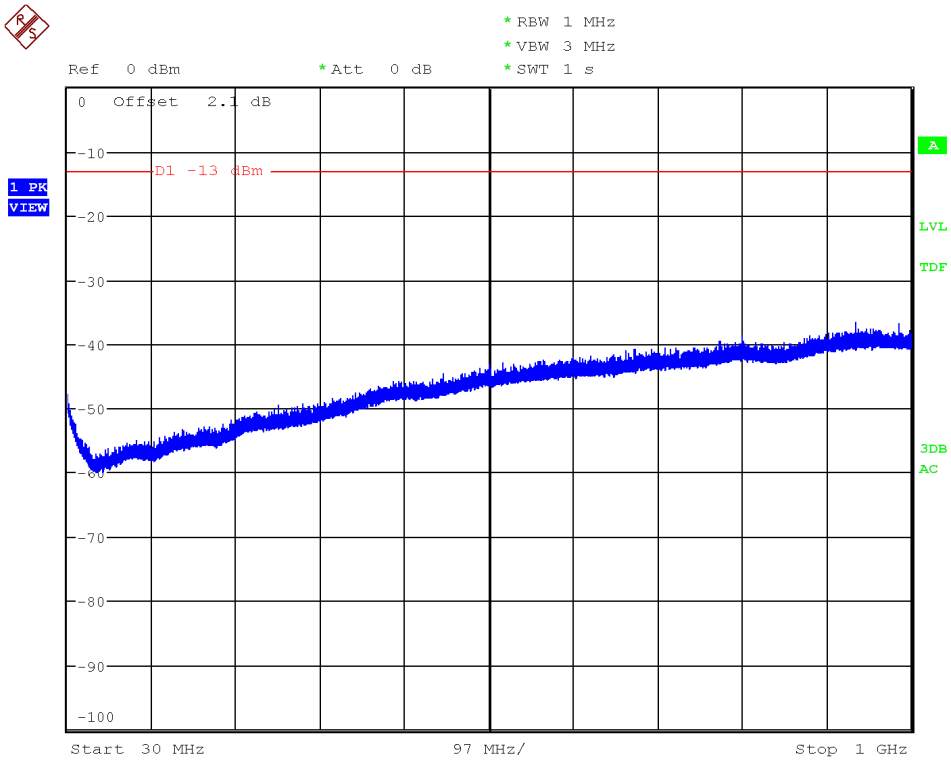
3. CHANNEL: HIGHEST
**Frequency range 30 MHz-1000 MHz.**
No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 1 GHz-18 GHz**.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 18 GHz-20 GHz.**
No radiated spurious signals were detected at less than 20 dB respect to the limit.

Verdict: PASS

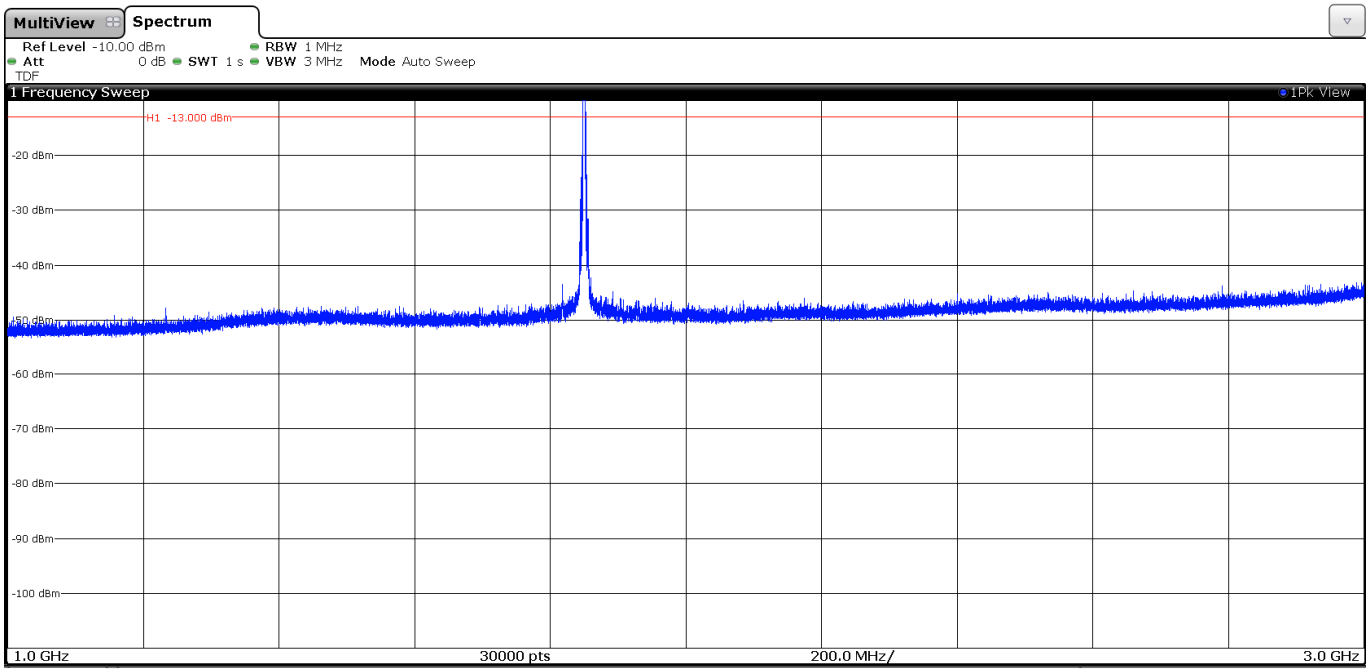
FREQUENCY RANGE 30 MHz-1000 MHz.




(This plot is valid for all three channels)

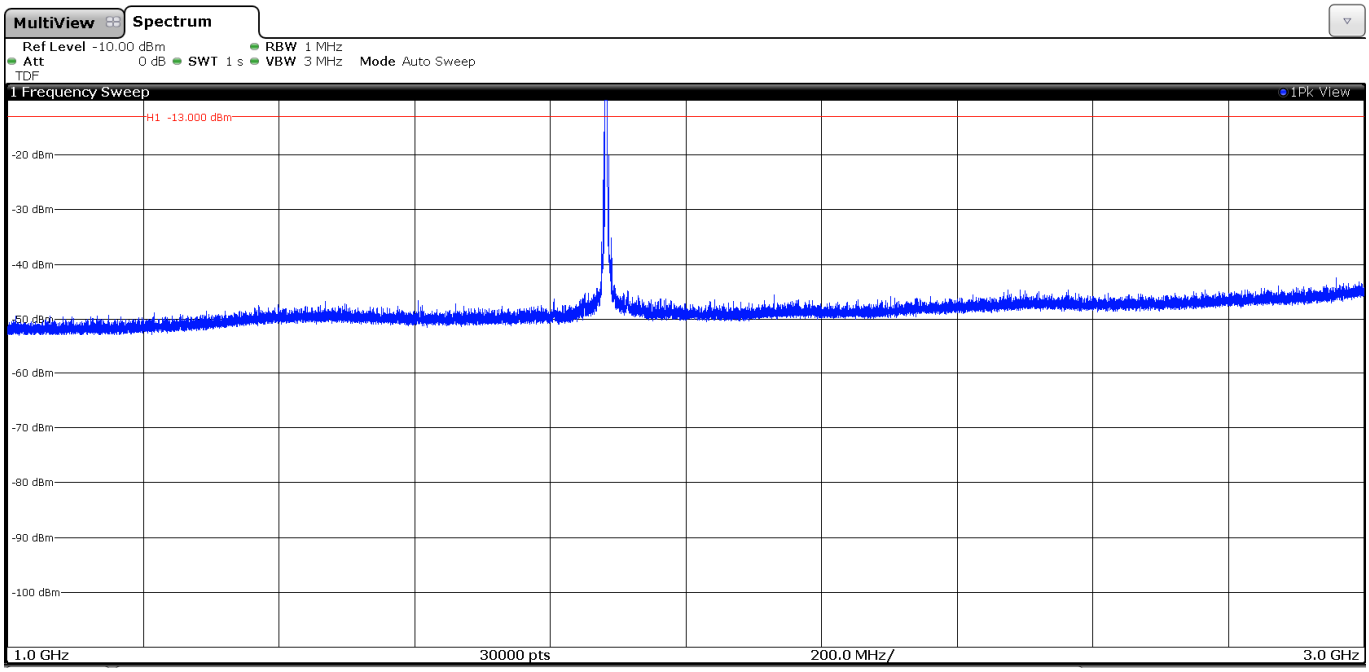
Frequency range 1 GHz to 3 GHz

CHANNEL: LOWEST



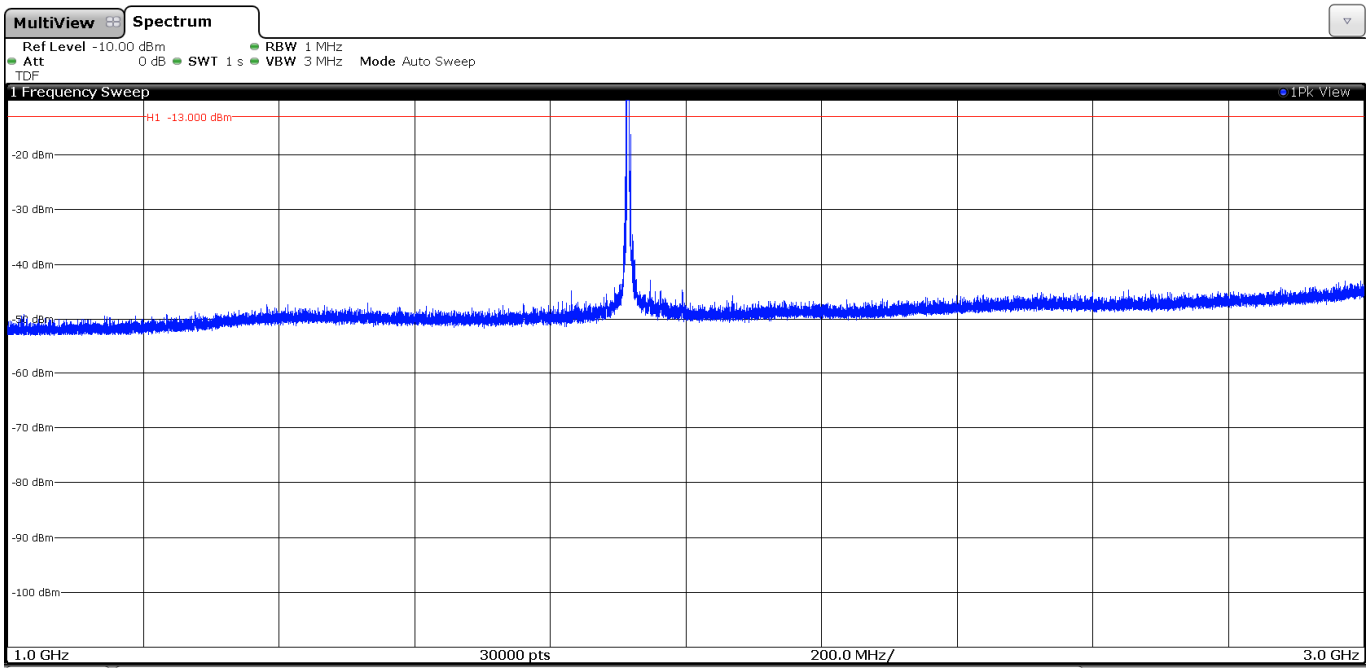

Note: The peak above the limit is the carrier frequency.

CHANNEL: MIDDLE




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

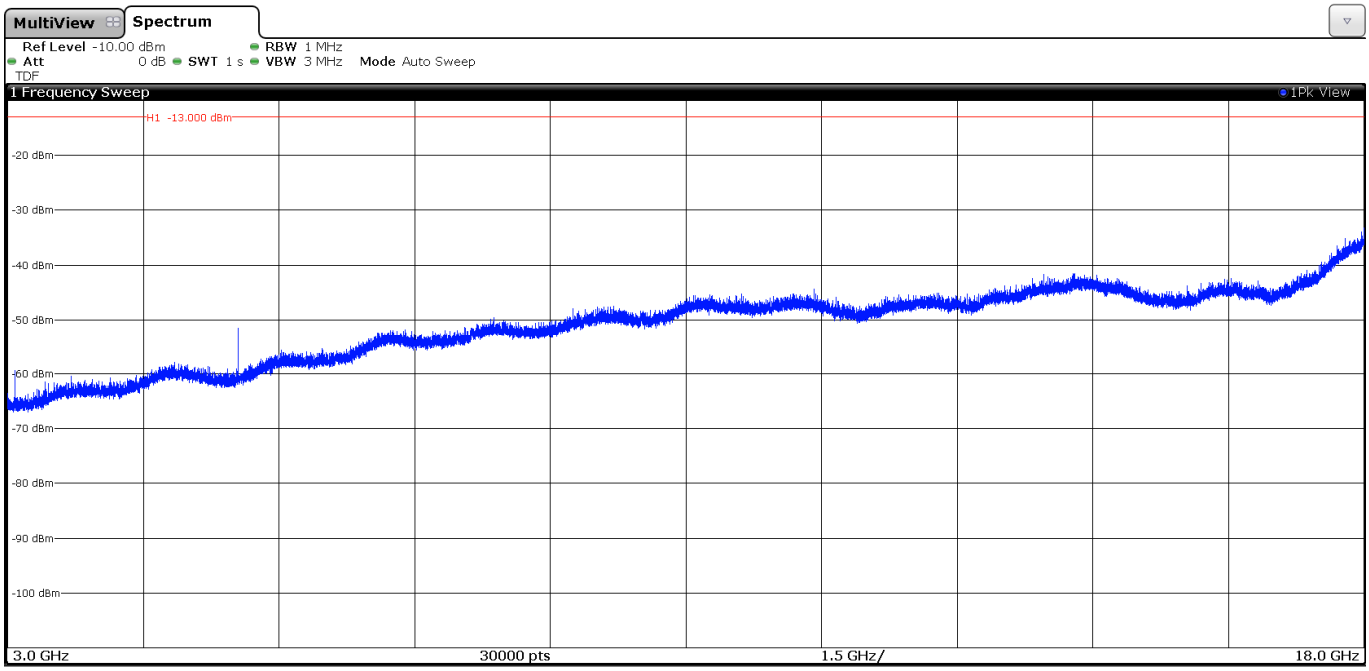
CHANNEL: HIGHEST



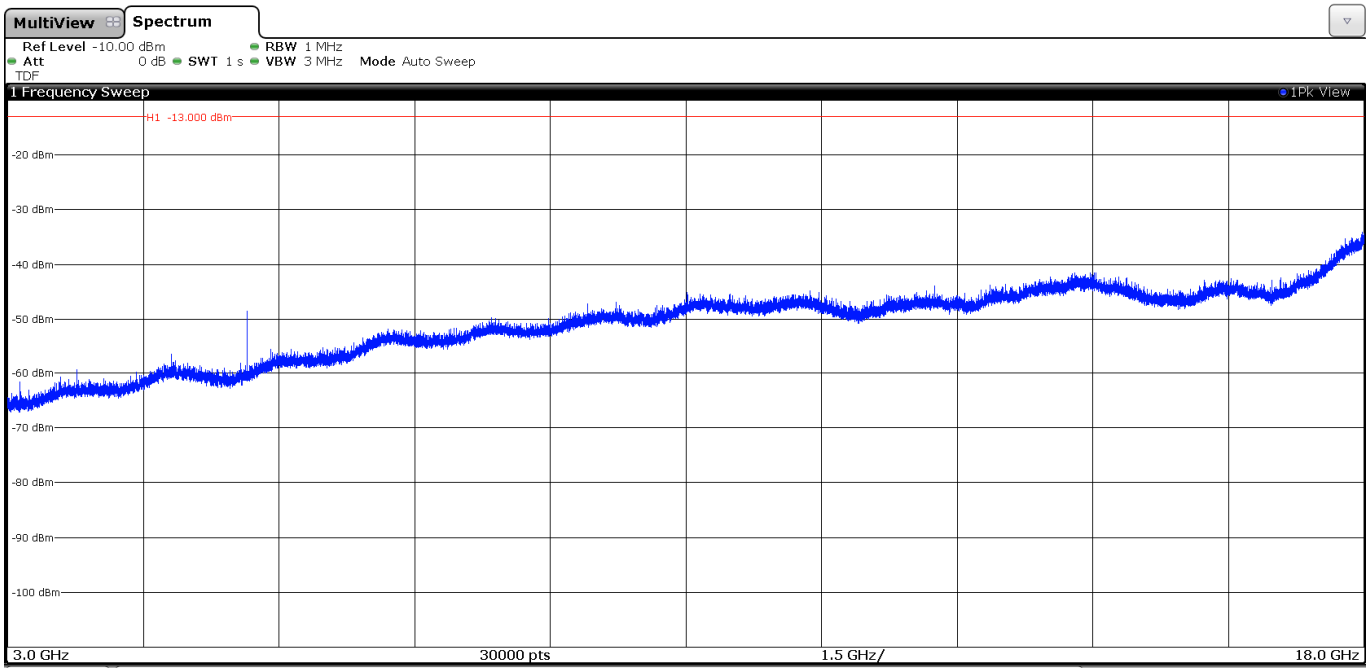

Note: The peak above the limit is the carrier frequency.

## Frequency range 3 GHz to 18 GHz

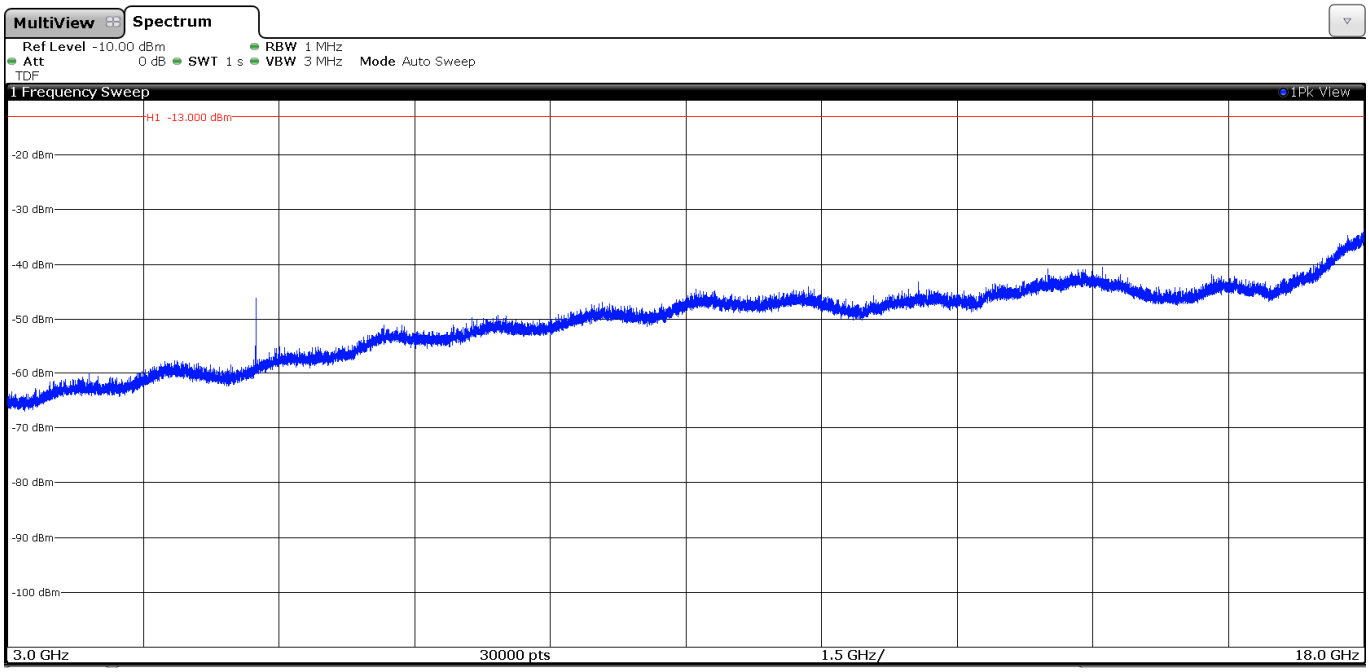
### CHANNEL: LOWEST



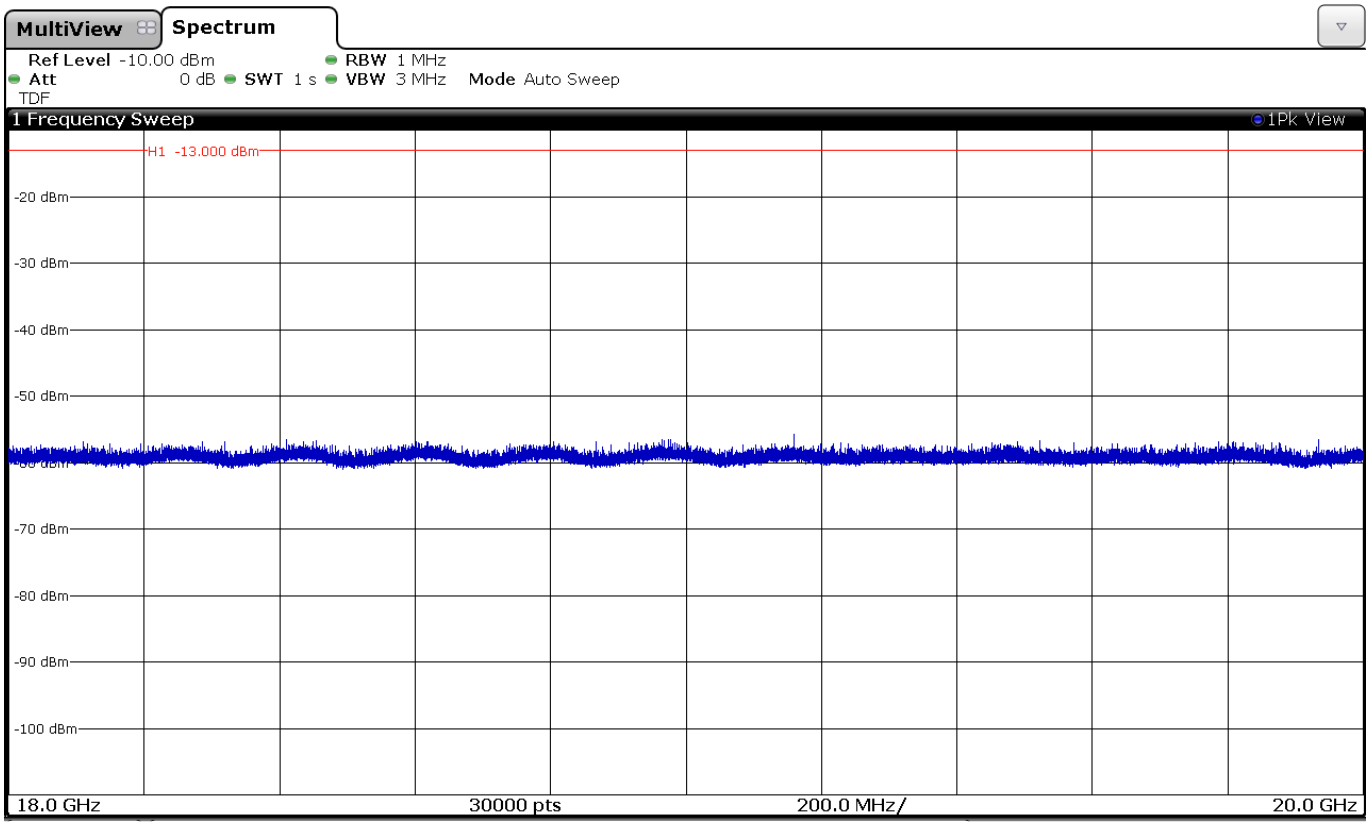

### CHANNEL: MIDDLE



CHANNEL: HIGHEST




Frequency range 18 GHz to 20 GHz




(This plot is valid for all three channels)

# **Appendix B:** Test results for FCC Part 27 / RSS-139 / RSS-130

# INDEX

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# TEST CONDITIONS

Power supply (V):

Vnominal = 3.8 Vdc

Vmax = 4.37 Vdc

Vmin = 3.23 Vdc

The subscripts nom. min and max indicate voltage test conditions (nominal. minimum and maximum respectively. as declared by the applicant).

Type of power supply = DC Voltage from external power supply

Type of antenna = Integral antenna.

Declared Gain for antenna = +2.6 dBi for Band 12. Band 13 and Band 17 and +4.4 dBi for Band 4 and Band 66.

TEST FREQUENCIES:

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 4)

| Channel (Frequency. MHz) | | |
|---|---|---|
| Lowest | Middle | Highest |
| 19952 (1710.2) | 20175 (1732.5) | 20398 (1754.8) |

NOTE: Band 4 is completely included in band 66. so the channels of band 66 were tested to give conformity to the assigned block

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 12)

| Channel (Frequency. MHz) | | |
|---|---|---|
| Lowest | Middle | Highest |
| 23012 (699.2) | 23095 (707.5) | 23178 (715.8) |

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 13)

| Channel (Frequency. MHz) | | |
|---|---|---|
| Lowest | Middle | Highest |
| 23182 (777.2) | 23230 (782) | 23278 (786.8) |

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 17)

| Channel (Frequency. MHz) | | |
|---|---|---|
| Lowest | Middle | Highest |
| 23732 (704.2) | 23790 (710) | 23848 (715.8) |

NOTE: Band 17 is completely included in band 12. so the channels of band 12 were tested to give conformity to the assigned block

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 66)

| Channel (Frequency. MHz) | | |
|---|---|---|
| Lowest | Middle | Highest |
| 131974 (1710.2) | 132322 (1745) | 132670 (1779.8) |

# RF Output Power

## SPECIFICATION

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.

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 Clause 4.4.
The e.i.r.p. shall not exceed 50 watts (46.99 dBm) for mobile equipment or for outdoor fixed subscriber equipment nor shall it exceed 5 watts (36.99 dBm) for portable equipment or for indoor fixed subscriber equipment.

The peak-to-average power ratio (PAPR) of the transmission shall not exceed 13 dB.

FCC §27.50 (d) (4). RSS-139 Clause 6.5.
Fixed. mobile. and portable (hand-held) stations operating in the 1710-1755 MHz band are limited to 1 watt EIRP (30 dBm). 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.

The peak-to-average ratio (PAR) of the transmission shall 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:

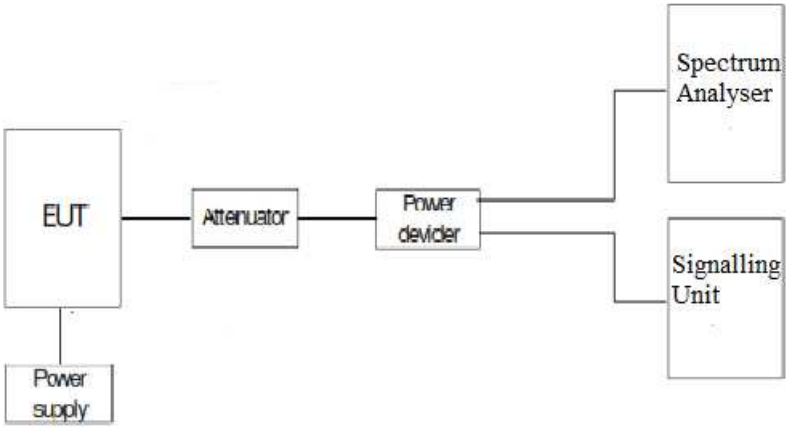
$$E.R.P. = E.I.R.P. – 2.15\ dB$$

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

Conducted average power.


Peak-to-average power ratio (PAPR)




RESULTS

MAXIMUM OUTPUT POWER (CONDUCTED).

NBIoT. BAND 12.

| Ch | Freq. (MHz) | Modulation | BW (kHz) | Num. tone | Offset Tone | Average Power (dBm) | PAPR (dB) |
|---|---|---|---|---|---|---|---|
| 23012 | 699.2 | π/2 - BPSK | 3.75 | 1 | 0 | 22.84 | (*) |
| | | | | 1 | 47 | 22.79 | (*) |
| | | | 15 | 1 | 0 | 22.95 | (*) |
| | | | | 1 | 11 | 22.95 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.9 | (*) |
| | | | | 1 | 47 | 22.81 | (*) |
| | | | 15 | 1 | 0 | 22.86 | (*) |
| | | | | 1 | 11 | 22.94 | (*) |
| | | | | 3 | 0 | 22.83 | 3.17 |
| | | | | 3 | 6 | 23.19 | 3.14 |
| | | | | 6 | 0 | 22.03 | 3.94 |
| | | | | 6 | 6 | 22.13 | 3.88 |
| | | | | 12 | 0 | 21.14 | 3.61 |
| 23095 | 707.5 | π/2 - BPSK | 3.75 | 1 | 0 | 23.01 | (*) |
| | | | | 1 | 47 | 23.11 | (*) |
| | | | 15 | 1 | 0 | 23.16 | (*) |
| | | | | 1 | 11 | 23.13 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 23.01 | (*) |
| | | | | 1 | 47 | 23.09 | (*) |
| | | | 15 | 1 | 0 | 23.15 | (*) |
| | | | | 1 | 11 | 23.1 | (*) |
| | | | | 3 | 0 | 22.97 | 3.21 |
| | | | | 3 | 6 | 23.17 | 3.17 |
| | | | | 6 | 0 | 21.97 | 3.89 |
| | | | | 6 | 6 | 21.98 | 3.96 |
| | | | | 12 | 0 | 20.95 | 3.88 |
| 23178 | 715.8 | π/2 - BPSK | 3.75 | 1 | 0 | 22.85 | (*) |
| | | | | 1 | 47 | 22.86 | (*) |
| | | | 15 | 1 | 0 | 22.83 | (*) |
| | | | | 1 | 11 | 22.82 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.81 | (*) |
| | | | | 1 | 47 | 22.85 | (*) |
| | | | 15 | 1 | 0 | 22.9 | (*) |
| | | | | 1 | 11 | 22.86 | (*) |
| | | | | 3 | 0 | 22.71 | 3.22 |
| | | | | 3 | 6 | 23.16 | 3.01 |
| | | | | 6 | 0 | 22.03 | 3.97 |
| | | | | 6 | 6 | 22.09 | 3.97 |
| | | | | 12 | 0 | 21.18 | 3.91 |

(*): Preliminary measurements determined that 3. 6 or 12 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

NBIoT. BAND 13.

| Ch | Freq. (MHz) | Modulation | BW (kHz) | Num. tone | Offset Tone | Average Power (dBm) | PAPR (dB) |
|---|---|---|---|---|---|---|---|
| 23182 | 777.20 | π/2 - BPSK | 3.75 | 1 | 0 | 22.97 | (*) |
| | | | | 1 | 47 | 22.95 | (*) |
| | | | 15 | 1 | 0 | 22.96 | (*) |
| | | | | 1 | 11 | 22.95 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 23.04 | (*) |
| | | | | 1 | 47 | 22.95 | (*) |
| | | | 15 | 1 | 0 | 23.14 | (*) |
| | | | | 1 | 11 | 23.12 | (*) |
| | | | | 3 | 0 | 22.76 | 3.19 |
| | | | | 3 | 6 | 23.22 | 3.08 |
| | | | | 6 | 0 | 22.13 | 3.86 |
| | | | | 6 | 6 | 22.21 | 3.85 |
| | | | | 12 | 0 | 21.22 | 3.53 |
| 23230 | 782 | π/2 - BPSK | 3.75 | 1 | 0 | 22.97 | (*) |
| | | | | 1 | 47 | 22.85 | (*) |
| | | | 15 | 1 | 0 | 22.92 | (*) |
| | | | | 1 | 11 | 22.89 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.93 | (*) |
| | | | | 1 | 47 | 22.87 | (*) |
| | | | 15 | 1 | 0 | 22.91 | (*) |
| | | | | 1 | 11 | 22.89 | (*) |
| | | | | 3 | 0 | 22.66 | 3.3 |
| | | | | 3 | 6 | 23.01 | 3.24 |
| | | | | 6 | 0 | 21.72 | 4.02 |
| | | | | 6 | 6 | 21.7 | 3.96 |
| | | | | 12 | 0 | 20.74 | 4.02 |
| 23278 | 786.8 | π/2 - BPSK | 3.75 | 1 | 0 | 23.1 | (*) |
| | | | | 1 | 47 | 23.03 | (*) |
| | | | 15 | 1 | 0 | 23.07 | (*) |
| | | | | 1 | 11 | 23.05 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 23.13 | (*) |
| | | | | 1 | 47 | 23.03 | (*) |
| | | | 15 | 1 | 0 | 23.05 | (*) |
| | | | | 1 | 11 | 23.13 | (*) |
| | | | | 3 | 0 | 22.9 | 3.24 |
| | | | | 3 | 6 | 23.26 | 3.09 |
| | | | | 6 | 0 | 22.18 | 3.86 |
| | | | | 6 | 6 | 22.26 | 3.83 |
| | | | | 12 | 0 | 21.29 | 3.8 |

(*): Preliminary measurements determined that 3, 6 or 12 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

NBIoT. BAND 66.

| Ch | Freq. (MHz) | Modulation | BW (kHz) | Num. tone | Offset Tone | Average Power (dBm) | PAPR (dB) |
|---|---|---|---|---|---|---|---|
| 131974 | 1710.2 | π/2 - BPSK | 3.75 | 1 | 0 | 22.96 | (*) |
| | | | | 1 | 47 | 22.92 | (*) |
| | | | 15 | 1 | 0 | 22.98 | (*) |
| | | | | 1 | 11 | 22.96 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.99 | (*) |
| | | | | 1 | 47 | 22.9 | (*) |
| | | | 15 | 1 | 0 | 22.99 | (*) |
| | | | | 1 | 11 | 22.96 | (*) |
| | | | | 3 | 0 | 22.83 | 3.45 |
| | | | | 3 | 6 | 23.31 | 3.13 |
| | | | | 6 | 0 | 22.2 | 4.05 |
| | | | | 6 | 6 | 22.29 | 4.04 |
| | | | | 12 | 0 | 21.19 | 3.78 |
| 132322 | 1745 | π/2 - BPSK | 3.75 | 1 | 0 | 22.75 | (*) |
| | | | | 1 | 47 | 22.69 | (*) |
| | | | 15 | 1 | 0 | 22.75 | (*) |
| | | | | 1 | 11 | 22.73 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.74 | (*) |
| | | | | 1 | 47 | 22.66 | (*) |
| | | | 15 | 1 | 0 | 22.73 | (*) |
| | | | | 1 | 11 | 22.72 | (*) |
| | | | | 3 | 0 | 22.4 | 3.32 |
| | | | | 3 | 6 | 22.46 | 3.3 |
| | | | | 6 | 0 | 21.55 | 4.41 |
| | | | | 6 | 6 | 21.54 | 4.33 |
| | | | | 12 | 0 | 20.54 | 4.28 |
| 132670 | 1779.8 | π/2 - BPSK | 3.75 | 1 | 0 | 23.11 | (*) |
| | | | | 1 | 47 | 23.03 | (*) |
| | | | 15 | 1 | 0 | 23.12 | (*) |
| | | | | 1 | 11 | 23.16 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 23.12 | (*) |
| | | | | 1 | 47 | 23.1 | (*) |
| | | | 15 | 1 | 0 | 23.13 | (*) |
| | | | | 1 | 11 | 23.1 | (*) |
| | | | | 3 | 0 | 22.98 | 3.38 |
| | | | | 3 | 6 | 23.39 | 3.24 |
| | | | | 6 | 0 | 22.21 | 4.41 |
| | | | | 6 | 6 | 22.38 | 4.28 |
| | | | | 12 | 0 | 21.26 | 4.29 |

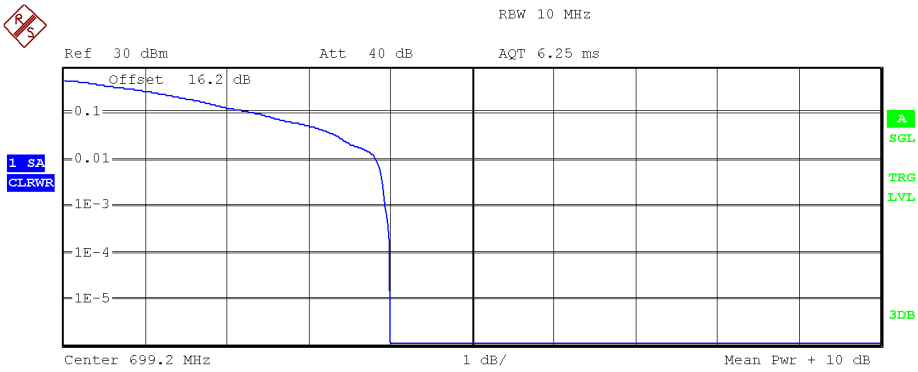
(*): Preliminary measurements determined that 3. 6 or 12 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

PEAK-TO-AVERAGE POWER RATIO (PAPR).

NBIoT BAND 12.

Preliminary measurements determined that 6 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

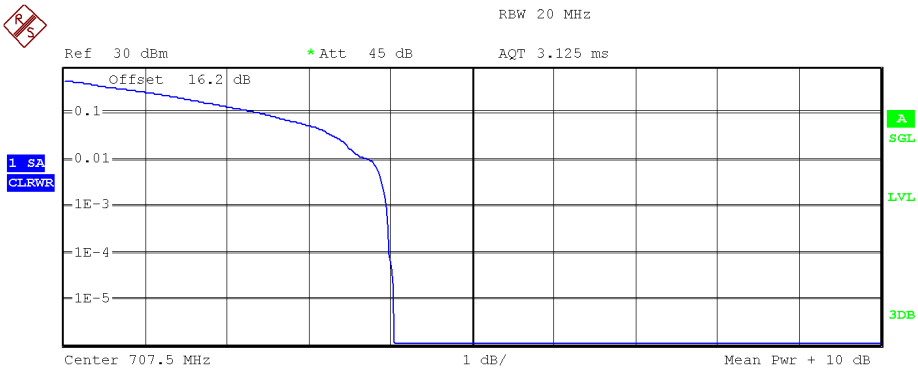
Channel Low:




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

| | Trace 1 |
|---|---|
| Mean | 21.92 dBm |
| Peak | 25.91 dBm |
| Crest | 4.00 dB |
| 10 % | 2.37 dB |
| 1 % | 3.83 dB |
| .1 % | 3.94 dB |
| .01 % | 4.01 dB |

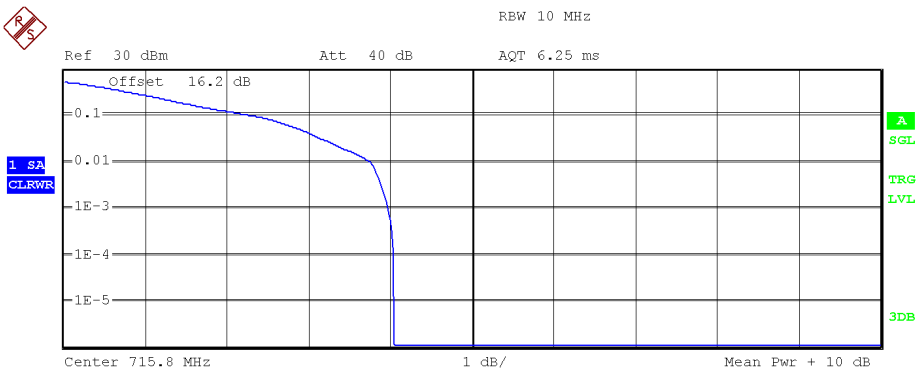
Channel Middle:




**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 23.7MHz**

| | Trace 1 |
|---|---|
| Mean | 22.00 dBm |
| Peak | 26.05 dBm |
| Crest | 4.05 dB |
| 10 % | 2.42 dB |
| 1 % | 3.73 dB |
| .1 % | 3.96 dB |
| .01 % | 3.99 dB |

Channel High:



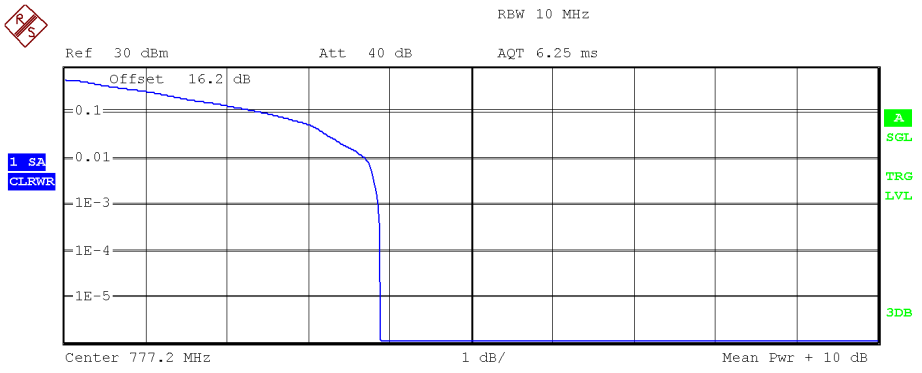

**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 11.2MHz**

| | Trace 1 |
|---|---|
| Mean | 22.07 dBm |
| Peak | 26.12 dBm |
| Crest | 4.04 dB |
| 10 % | 2.29 dB |
| 1 % | 3.75 dB |
| .1 % | 3.97 dB |
| .01 % | 4.04 dB |

NBIoT. BAND 13.

Preliminary measurements determined that 6 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

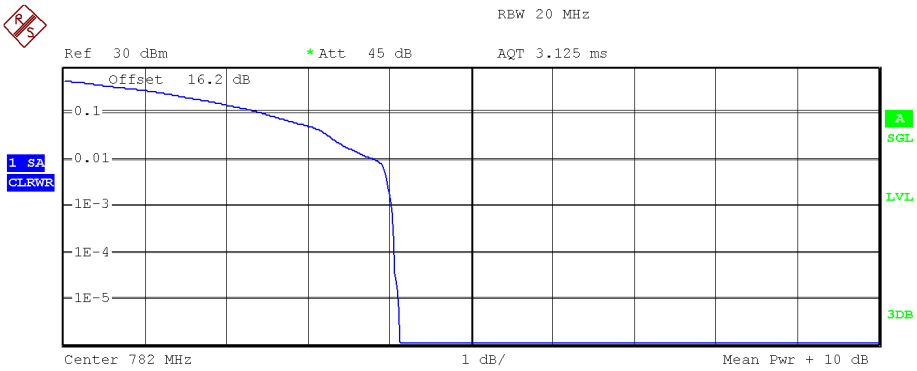
Channel Low:




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

| | Trace 1 |
|---|---|
| Mean | 22.10 dBm |
| Peak | 25.98 dBm |
| Crest | 3.88 dB |
| 10 % | 2.45 dB |
| 1 % | 3.70 dB |
| .1 % | 3.86 dB |
| .01 % | 3.89 dB |

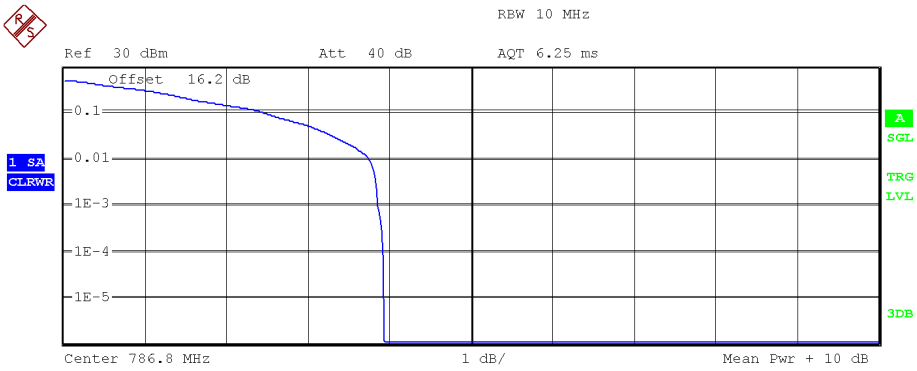
Channel Middle:




**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 23.7MHz**

| | Trace 1 |
|---|---|
| Mean | 21.79 dBm |
| Peak | 25.92 dBm |
| Crest | 4.12 dB |
| 10 % | 2.45 dB |
| 1 % | 3.83 dB |
| .1 % | 4.02 dB |
| .01 % | 4.07 dB |

Channel High:



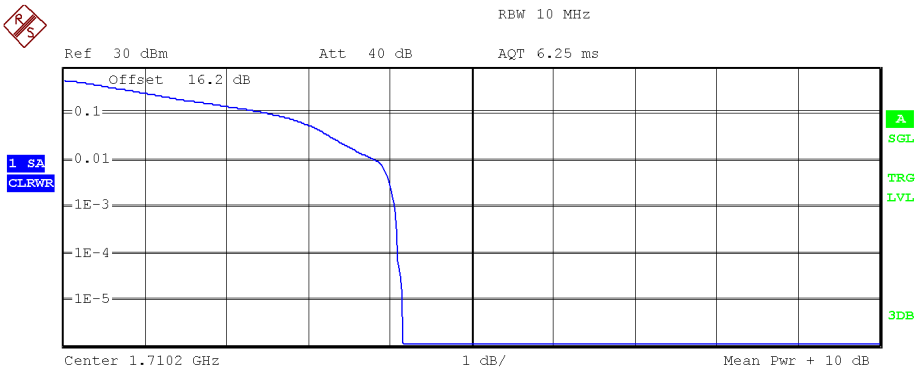

**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 11.2MHz**

| | Trace 1 |
|---|---|
| Mean | 22.06 dBm |
| Peak | 25.98 dBm |
| Crest | 3.93 dB |
| 10 % | 2.47 dB |
| 1 % | 3.75 dB |
| .1 % | 3.86 dB |
| .01 % | 3.93 dB |

NBIoT. BAND 66.

Preliminary measurements determined that 6 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

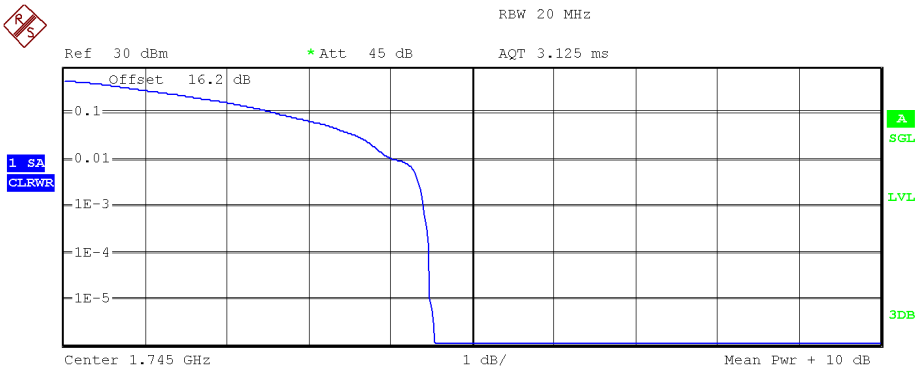
Channel Low:




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

| | Trace 1 |
|---|---|
| Mean | 21.77 dBm |
| Peak | 25.93 dBm |
| Crest | 4.16 dB |
| 10 % | 2.53 dB |
| 1 % | 3.83 dB |
| .1 % | 4.05 dB |
| .01 % | 4.10 dB |

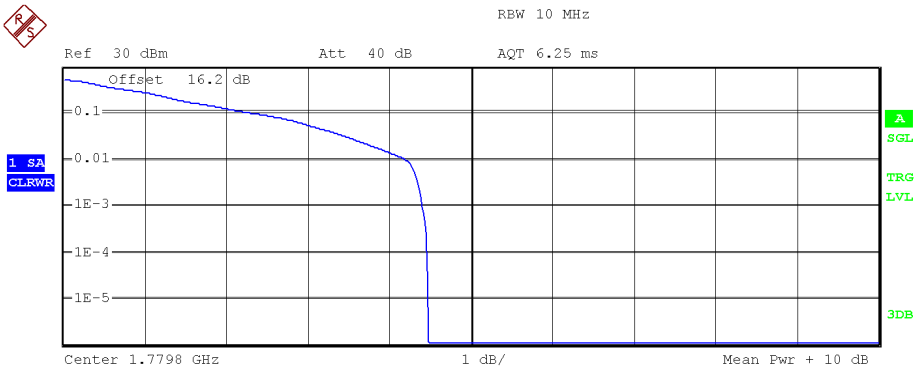
Channel Middle:




**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 23.7MHz**

| | Trace 1 |
|---|---|
| Mean | 21.68 dBm |
| Peak | 26.24 dBm |
| Crest | 4.55 dB |
| 10 % | 2.61 dB |
| 1 % | 4.07 dB |
| .1 % | 4.41 dB |
| .01 % | 4.47 dB |

Channel High:




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

| | Trace 1 |
|---|---|
| Mean | 22.06 dBm |
| Peak | 26.53 dBm |
| Crest | 4.47 dB |
| 10 % | 2.34 dB |
| 1 % | 4.20 dB |
| .1 % | 4.41 dB |
| .01 % | 4.47 dB |

NBIoT BAND 12.

| Channel | Measured maximum average power (dBm) at antenna port | Maximum declared antenna gain (dBi) | Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm) | Maximum effective radiated power E.R.P. (dBm) | PAPR (dB) |
|---|---|---|---|---|---|
| Lowest | 23.19 | +2.6 | 25.79 | 23.64 | 3.94 |
| Middle | 23.17 | +2.6 | 25.77 | 23.62 | 3.96 |
| Highest | 23.16 | +2.6 | 25.76 | 23.61 | 3.97 |
| Measurement uncertainty (dB) | <±1.11 | | | | |

NBIoT BAND 13.

| Channel | Measured maximum average power (dBm) at antenna port | Maximum declared antenna gain (dBi) | Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm) | Maximum effective radiated power E.R.P. (dBm) | PAPR (dB) |
|---|---|---|---|---|---|
| Lowest | 23.22 | +2.6 | 25.82 | 23.67 | 3.86 |
| Middle | 23.01 | +2.6 | 25.61 | 23.46 | 4.02 |
| Highest | 23.26 | +2.6 | 25.86 | 23.71 | 3.86 |
| Measurement uncertainty (dB) | <±1.11 | | | | |

NBIoT BAND 66.

| Channel | Measured maximum average power (dBm) at antenna port | Maximum declared antenna gain (dBi) | Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm) | Maximum effective radiated power E.R.P. (dBm) | PAPR (dB) |
|---|---|---|---|---|---|
| Lowest | 23.31 | +4.4 | 27.71 | 25.56 | 4.05 |
| Middle | 22.76 | +4.4 | 27.16 | 25.01 | 4.41 |
| Highest | 23.39 | +4.4 | 27.9 | 25.64 | 4.41 |
| Measurement uncertainty (dB) | <±1.11 | | | | |

Verdict: PASS

# Frequency Stability

SPECIFICATION

FCC §2.1055 and §27.54.

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

RSS-130. Clause 4.3.

The applicant shall ensure frequency stability by showing that fL minus the frequency offset and fH plus the frequency offset shall be within the frequency range in which the equipment is designed to operate.

RSS-139 Clause 6.4.

The frequency stability shall be sufficient to ensure that the occupied bandwidth stays within the operating frequency block 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 –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.

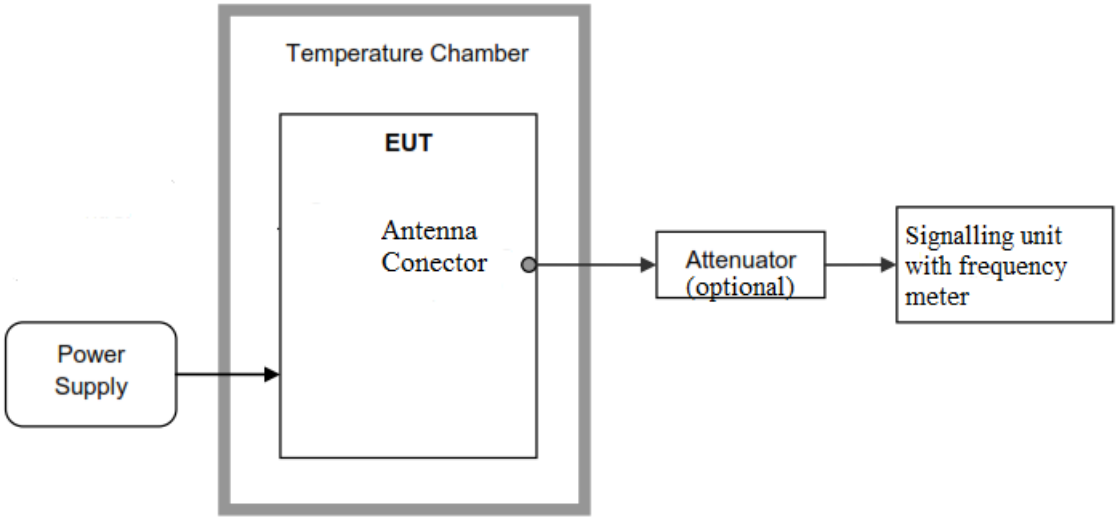
The EUT was set in “Radio Resource Control (RRC) mode” in the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case NBIoT mode for conducted power was used for the test.

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.

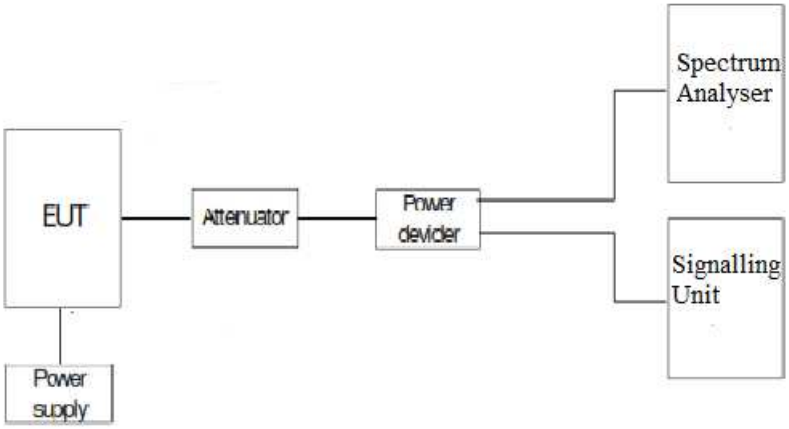
The reference point measurements were made at the RF output terminals of the EUT using an attenuator. power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

TEST SETUP

Frequency tolerance.




Reference points *f*L and *fH.*



RESULTS

Frequency stability over temperature variations.

NBIoT Band 12

| Temperature (ºC) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|
| +50 | 7.25 | 0.01024735 |
| +40 | 16.01 | 0.022628975 |
| +30 | 8.31 | 0.011745583 |
| +20 | 5.81 | 0.008212014 |
| +10 | 12.89 | 0.018219081 |
| 0 | 2.15 | 0.003038869 |
| -10 | 5.41 | 0.007646643 |
| -20 | -2.8 | -0.003957597 |
| -30 | 19.6 | 0.02770318 |

NBIoT Band 13

| Temperature (ºC) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|
| +50 | 7.18 | 0.009181586 |
| +40 | 28.45 | 0.036381074 |
| +30 | 8.38 | 0.010716113 |
| +20 | 1.6 | 0.002046036 |
| +10 | 16.75 | 0.021419437 |
| 0 | -2.1 | -0.002685422 |
| -10 | 8.58 | 0.010971867 |
| -20 | -19.57 | -0.025025575 |
| -30 | 37.62 | 0.048107417 |

NBIoT Band 66

| Temperature (ºC) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|
| +50 | 20.97 | 0.012017192 |
| +40 | 27.64 | 0.015839542 |
| +30 | -23.99 | -0.013747851 |
| +20 | 11.46 | 0.006567335 |
| +10 | 25.42 | 0.014567335 |
| 0 | 17.6 | 0.01008596 |
| -10 | 28.17 | 0.016143266 |
| -20 | -16.06 | -0.009203438 |
| -30 | 30.4 | 0.017421203 |

Frequency stability over voltage variations.

NBIoT Band 12

| Battery Supply voltage | Voltage (V) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|---|
| Vmax | 4.37 | 7.71 | 0.010897527 |
| Vmin | 3.23 | 9.21 | 0.013017668 |

NBIoT Band 13

| Battery Supply voltage | Voltage (V) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|---|
| Vmax | 4.37 | 2.13 | 0.002723785 |
| Vmin | 3.23 | 4.88 | 0.006240409 |

NBIoT Band 66

| Battery Supply voltage | Voltage (V) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|---|
| Vmax | 4.37 | 13.7 | 0.007851003 |
| Vmin | 3.23 | 9.56 | 0.00547851 |

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

| | NBIoT Band 12 |
|---|---|
| *f*L (MHz) | 698.9357 |
| *fH (MHz)* | 715.9913 |

| | NBIoT Band 13 |
|---|---|
| *f*L (MHz) | 777.0074 |
| *fH (MHz)* | 786.9911 |

| | NBIoT Band 66 |
|---|---|
| *f*L (MHz) | 1710.0383 |
| *fH (MHz)* | 1779.9623 |

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

| | NBIoT Band 12 |
|---|---|
| *f*L (MHz) | 698.9357 |
| *fH (MHz)* | 715.9913 |

| | NBIoT Band 13 |
|---|---|
| *f*L (MHz) | 777.0074 |
| *fH (MHz)* | 786.9911 |

| | NBIoT Band 66 |
|---|---|
| *f*L (MHz) | 1710.0383 |
| *fH (MHz)* | 1779.9624 |

The reference frequency points stay within the authorized blocks.

Verdict: PASS

# Modulation Characteristics

## SPECIFICATION

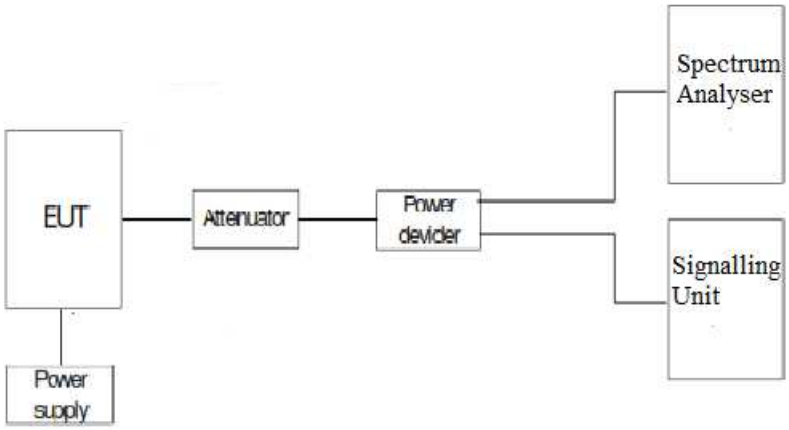
FCC §2.1047

RSS-130. Clause 4.1 and RSS-133. Clause 6.2. Equipment certified under this standard shall use digital modulation.

## METHOD

For NBIoT the EUT operates with π/2 - BPSK and π/4 - QPSK modulation modes in which the information is digitised and coded into a bit stream.

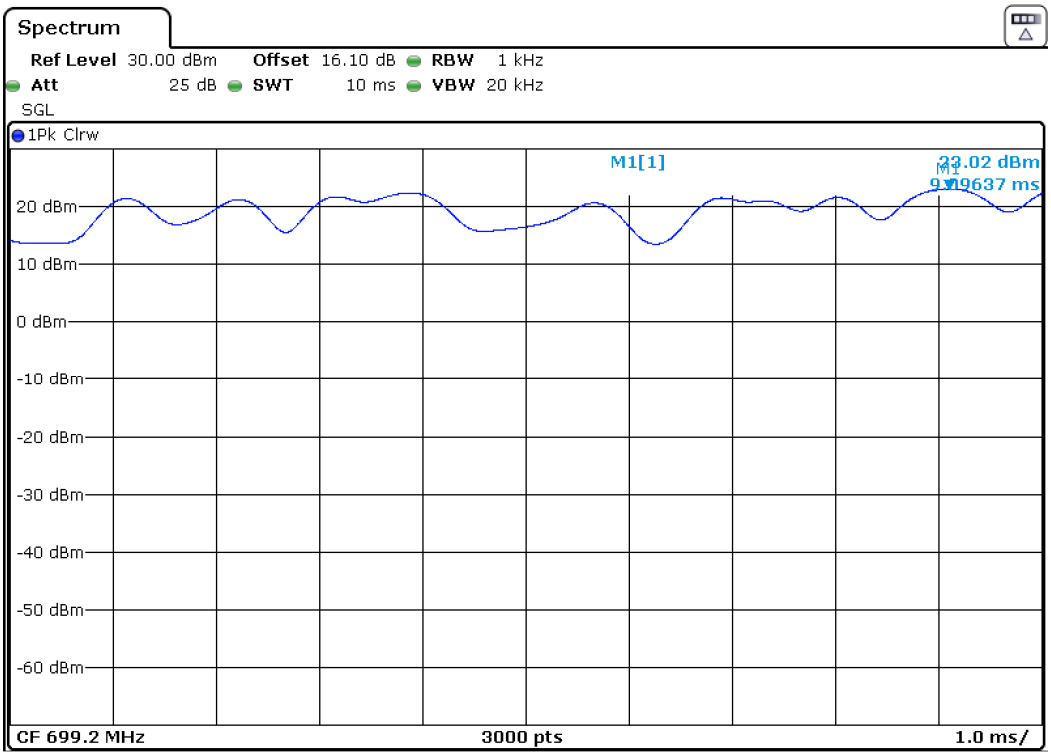
## TEST SETUP



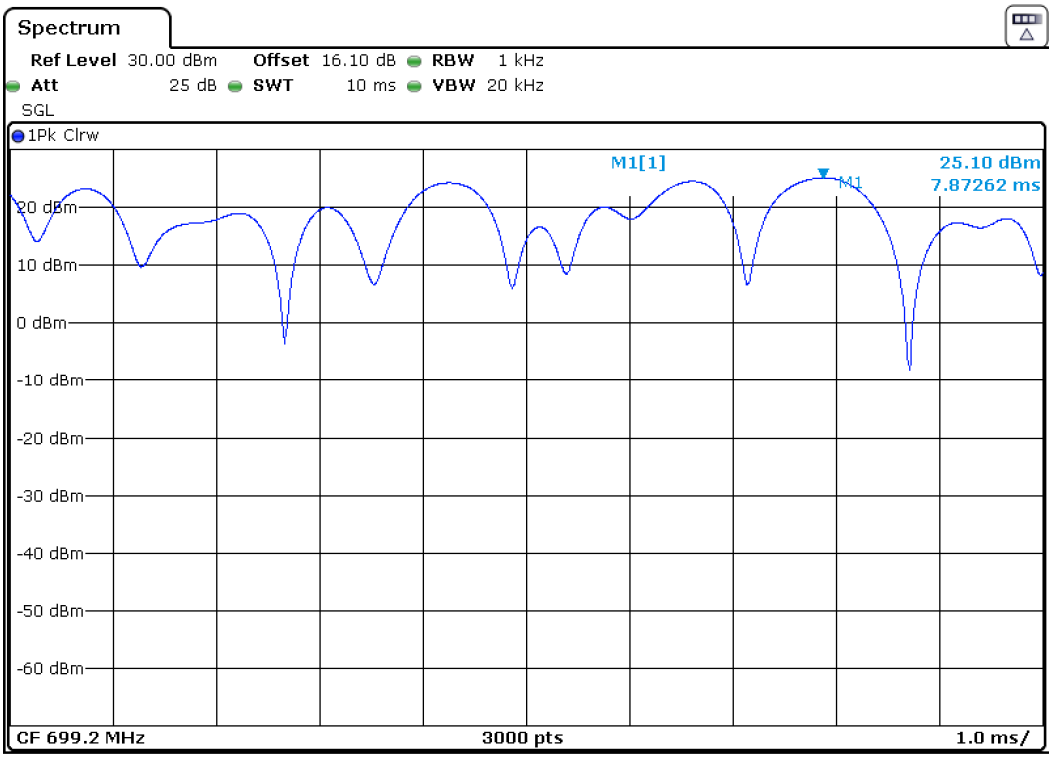

## RESULTS

The following plot shows the modulation schemes in the EUT.

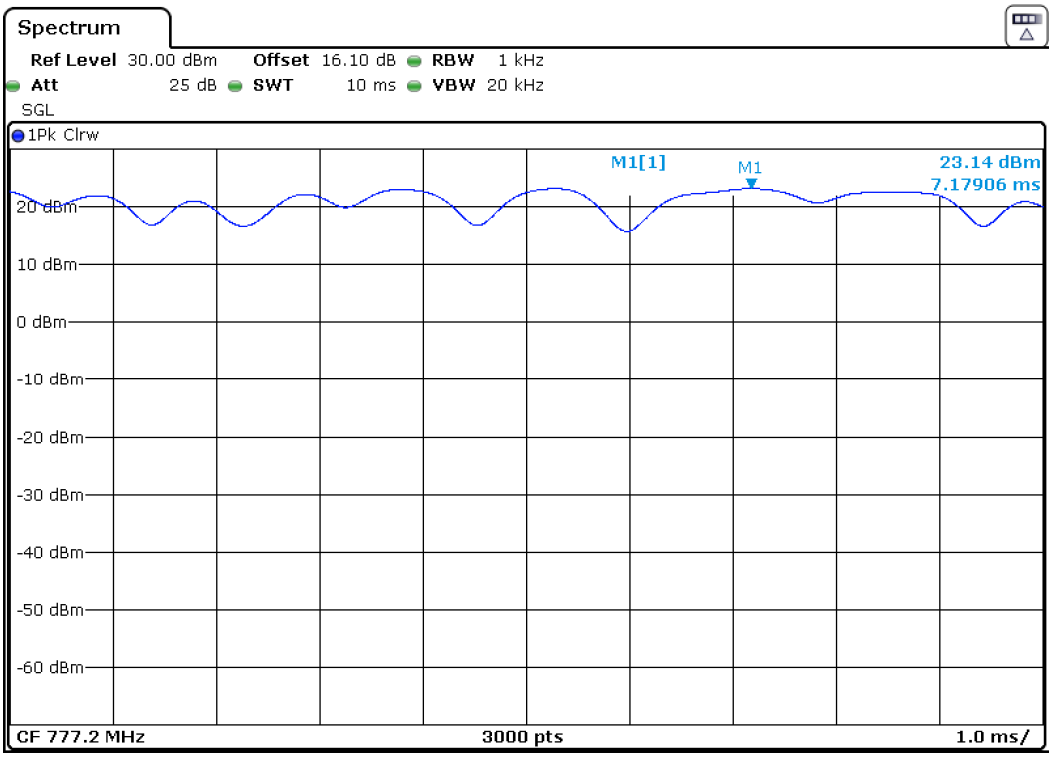
NBIoT MODULATION (Band 12). π/2 - BPSK.



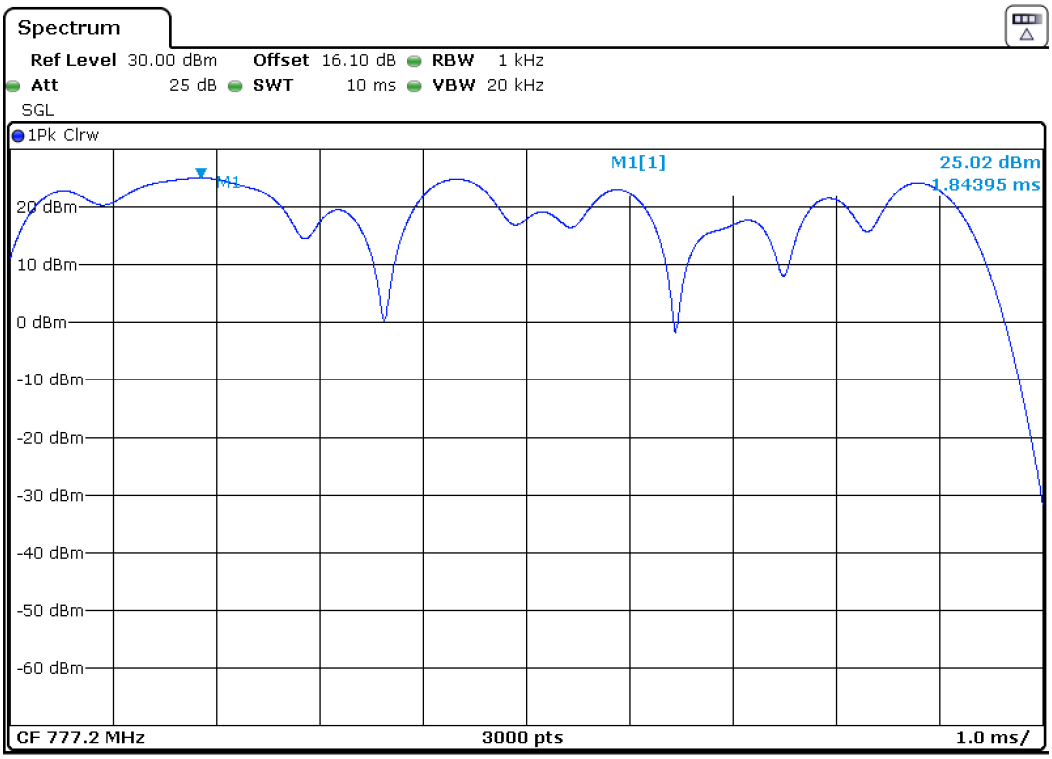

NBIoT MODULATION (Band 12). π/4 - QPSK.



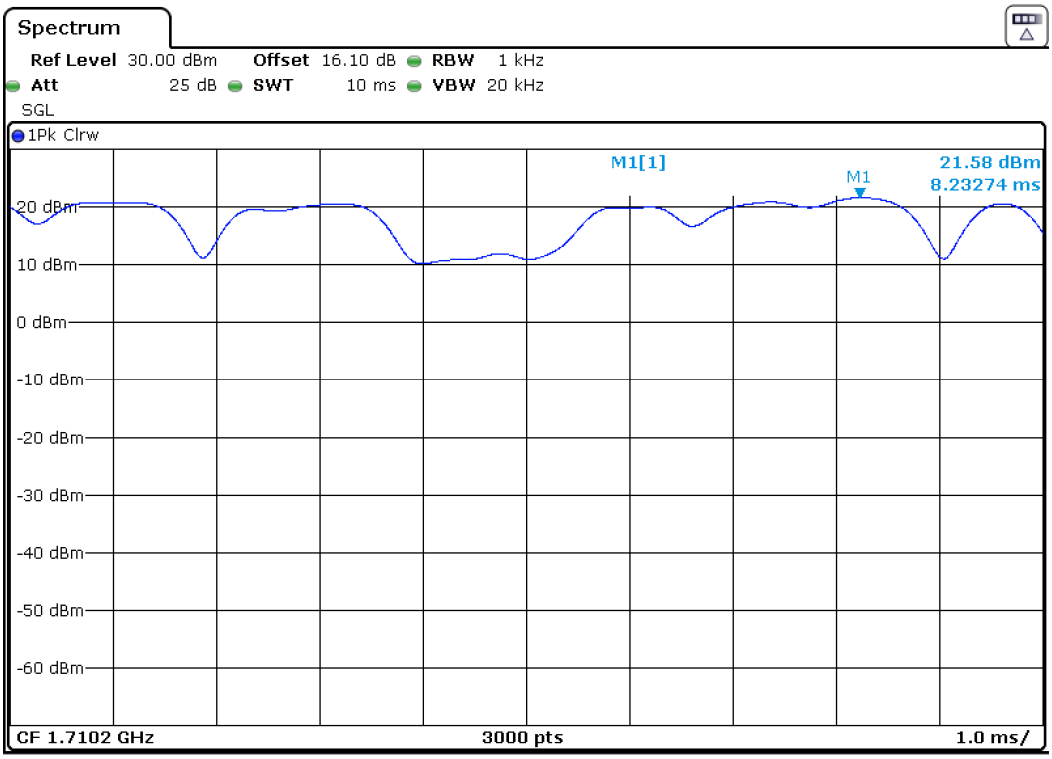
NBIoT MODULATION (Band 13). π/2 - BPSK.



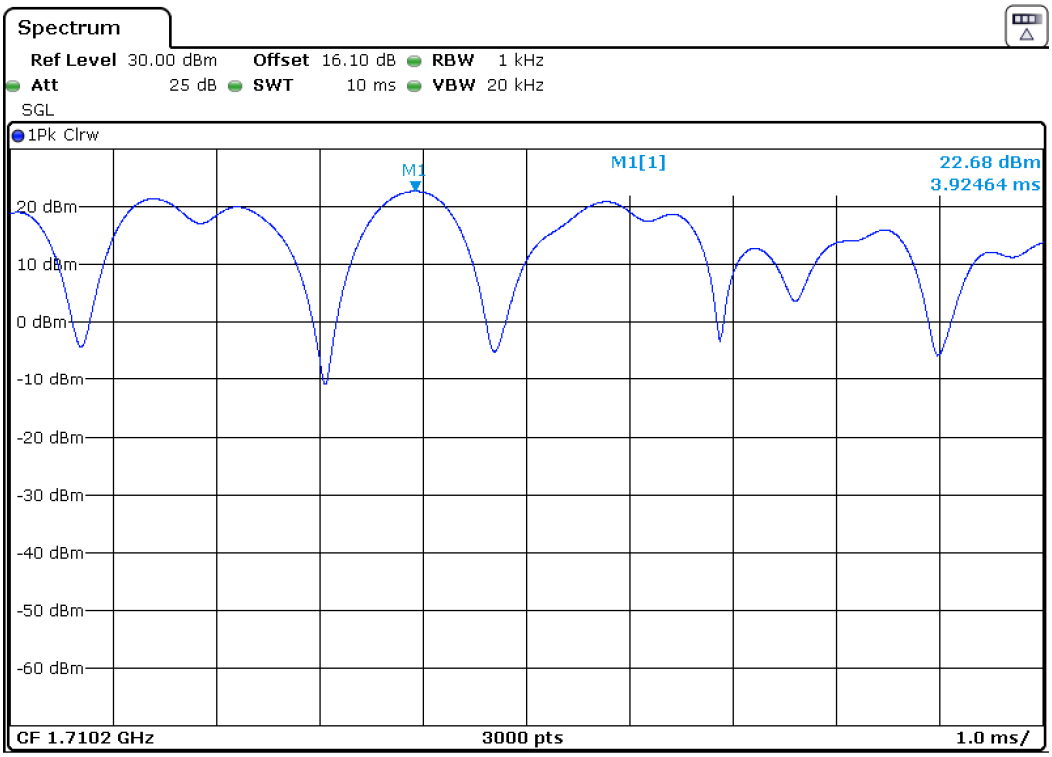

NBIoT MODULATION (Band 13). π/4 - QPSK.



NBIoT MODULATION (Band 66). π/2 - BPSK.




NBIoT MODULATION (Band 66). π/4 - QPSK.



# Occupied Bandwidth

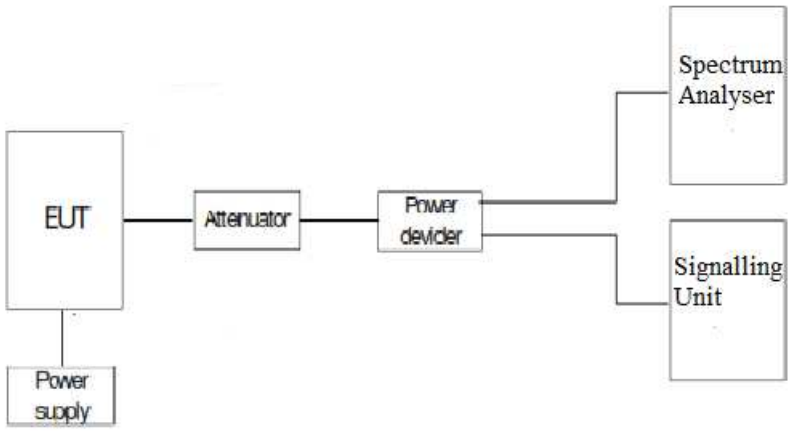
## SPECIFICATION

§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)

NBIoT BAND 12.

Tone 3.75 kHz. π/2 - BPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 57.60 | 57.60 | 57.86 |
| -26 dBc bandwidth (kHz) | 41.533 | 41.533 | 41.467 |
| Measurement uncertainty (kHz) | <±0.05 | | |

Tone 3.75 kHz. π/4 - QPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 61.86 | 61.93 | 62.00 |
| -26 dBc bandwidth (kHz) | 41.933 | 41.867 | 41.867 |
| Measurement uncertainty (kHz) | <±0.05 | | |

Tone 15 kHz. π/2 - BPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 137.60 | 137.60 | 137.73 |
| -26 dBc bandwidth (kHz) | 127.27 | 127.33 | 127.47 |
| Measurement uncertainty (kHz) | <±0.10 | | |

12 Tones 15 kHz. π/4 - QPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 202.53 | 202.53 | 202.53 |
| -26 dBc bandwidth (kHz) | 307.60 | 308.27 | 300.27 |
| Measurement uncertainty (kHz) | <±0.12 | | |

NBIoT BAND 13.

Tone 3.75 kHz. π/2 - BPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 58.60 | 58.66 | 58.80 |
| -26 dBc bandwidth (kHz) | 41.467 | 41.533 | 41.533 |
| Measurement uncertainty (kHz) | <±0.05 | | |

Tone 3.75 kHz. π/4 - QPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 62.46 | 62.40 | 62.66 |
| -26 dBc bandwidth (kHz) | 41.867 | 41.867 | 41.867 |
| Measurement uncertainty (kHz) | <±0.05 | | |

Tone 15 kHz. π/2 - BPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 138.53 | 138.93 | 138.66 |
| -26 dBc bandwidth (kHz) | 127.47 | 127.47 | 127.47 |
| Measurement uncertainty (kHz) | <±0.10 | | |

12 Tones 15 kHz. π/4 - QPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 203.33 | 202 | 203.46 |
| -26 dBc bandwidth (kHz) | 326.93 | 308.40 | 317.33 |
| Measurement uncertainty (kHz) | <±0.12 | | |

NBIoT BAND 66.

Tone 3.75 kHz. π/2 - BPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 59.20 | 59.73 | 59.40 |
| -26 dBc bandwidth (kHz) | 41.467 | 41.33 | 41.40 |
| Measurement uncertainty (kHz) | <±0.05 | | |

Tone 3.75 kHz. π/4 - QPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 62.53 | 62.66 | 62.60 |
| -26 dBc bandwidth (kHz) | 41.80 | 41.80 | 42.00 |
| Measurement uncertainty (kHz) | <±0.05 | | |

Tone 15 kHz. π/2 - BPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 140.53 | 139.86 | 139.06 |
| -26 dBc bandwidth (kHz) | 127.78 | 127.60 | 127.60 |
| Measurement uncertainty (kHz) | <±0.10 | | |

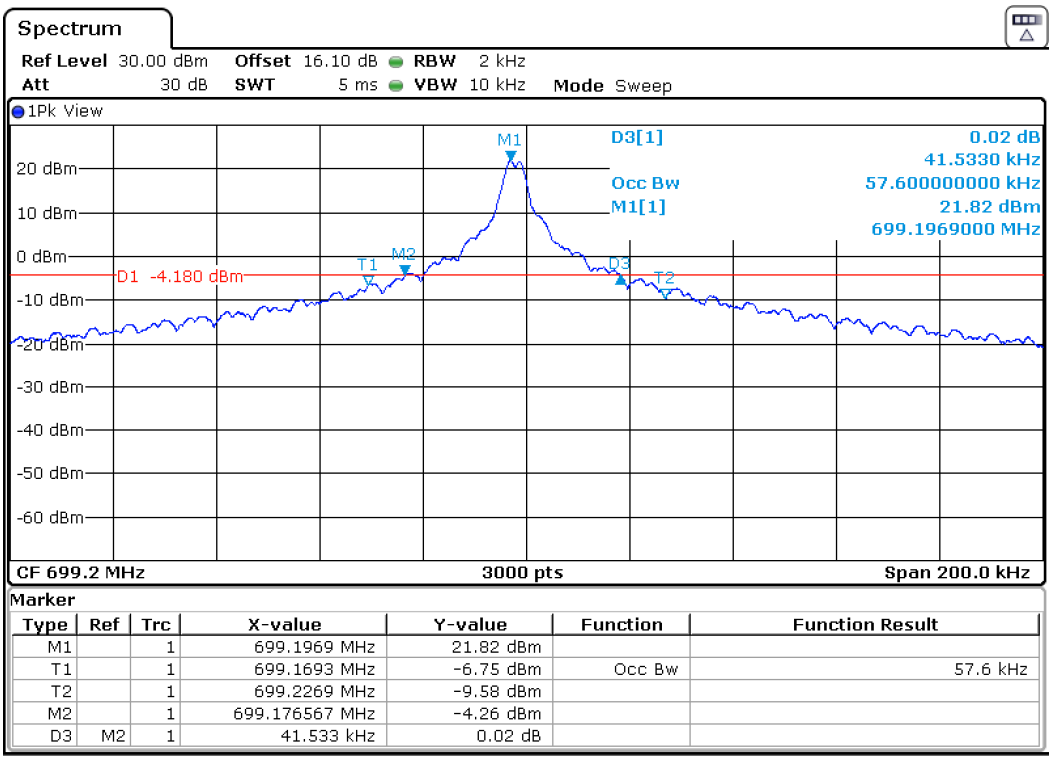
12 Tones 15 kHz. π/4 - QPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 203.20 | 204.26 | 203.33 |
| -26 dBc bandwidth (kHz) | 325.33 | 320.80 | 322.40 |
| Measurement uncertainty (kHz) | <±0.12 | | |

NBIoT BAND 12.

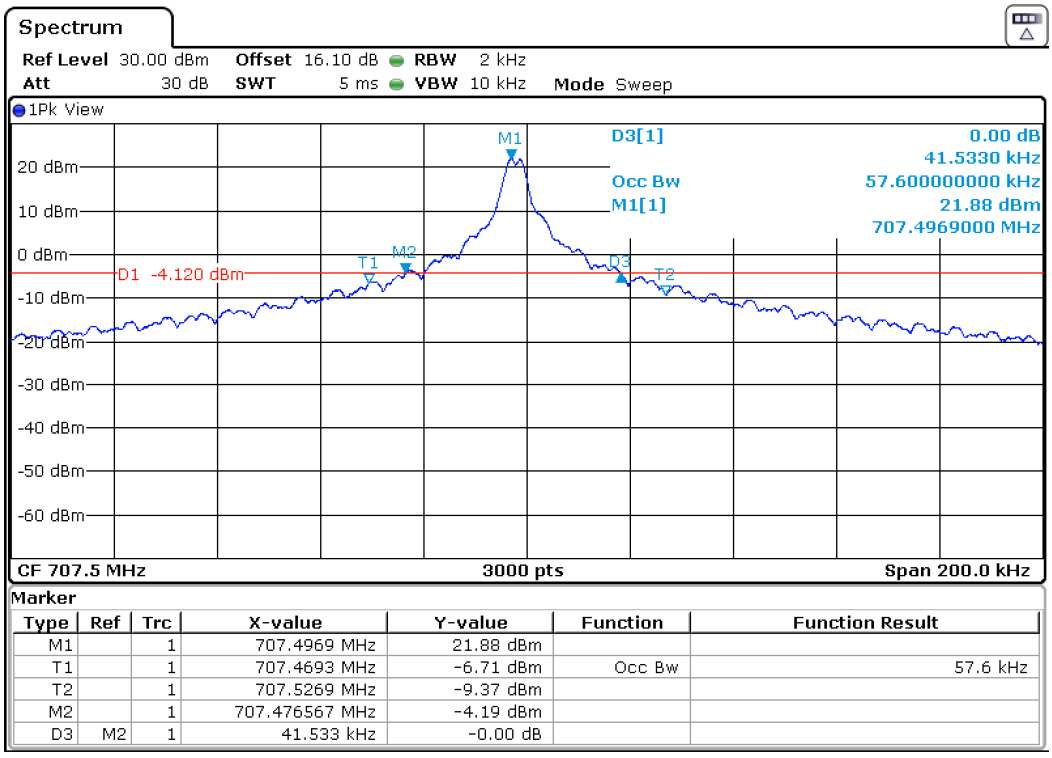
Tone 3.75 kHz. π/2 - BPSK MODULATION

Lowest Channel



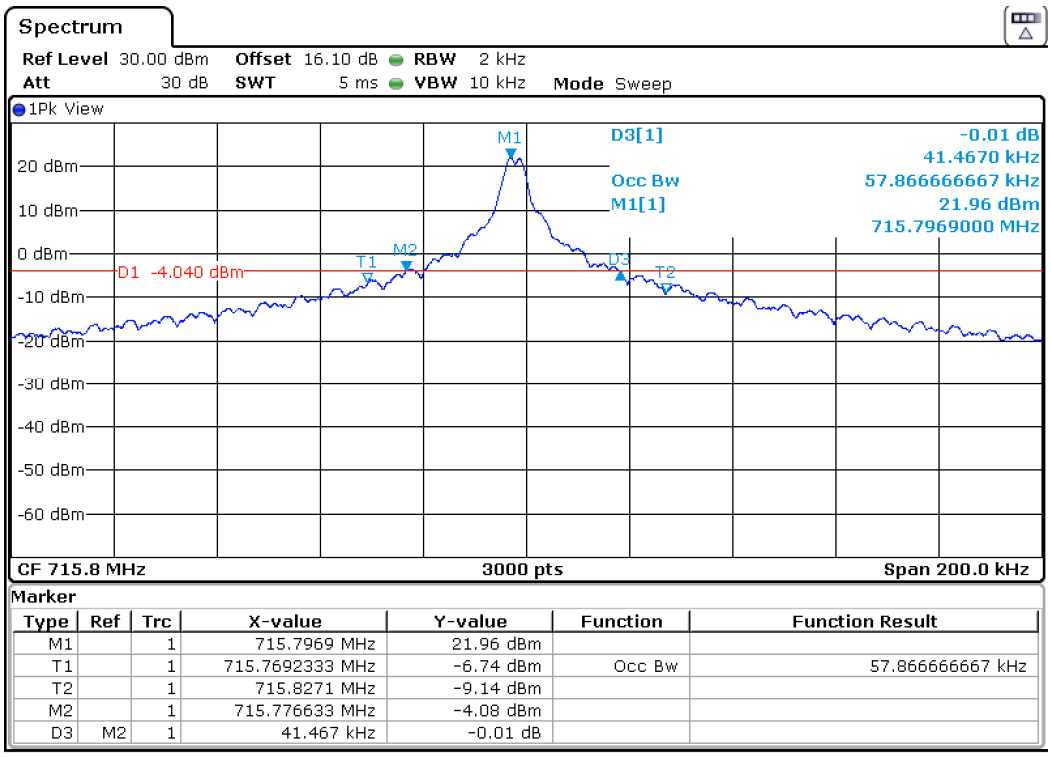

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 699.1969 MHz | 21.82 dBm | | |
| T1 | | 1 | 699.1693 MHz | -6.75 dBm | Occ Bw | 57.6 kHz |
| T2 | | 1 | 699.2269 MHz | -9.58 dBm | | |
| M2 | | 1 | 699.176567 MHz | -4.26 dBm | | |
| D3 | M2 | 1 | 41.533 kHz | 0.02 dB | | |

Middle Channel




| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 707.4969 MHz | 21.88 dBm | | |
| T1 | | 1 | 707.4693 MHz | -6.71 dBm | Occ Bw | 57.6 kHz |
| T2 | | 1 | 707.5269 MHz | -9.37 dBm | | |
| M2 | | 1 | 707.476567 MHz | -4.19 dBm | | |
| D3 | M2 | 1 | 41.533 kHz | -0.00 dB | | |

Highest Channel

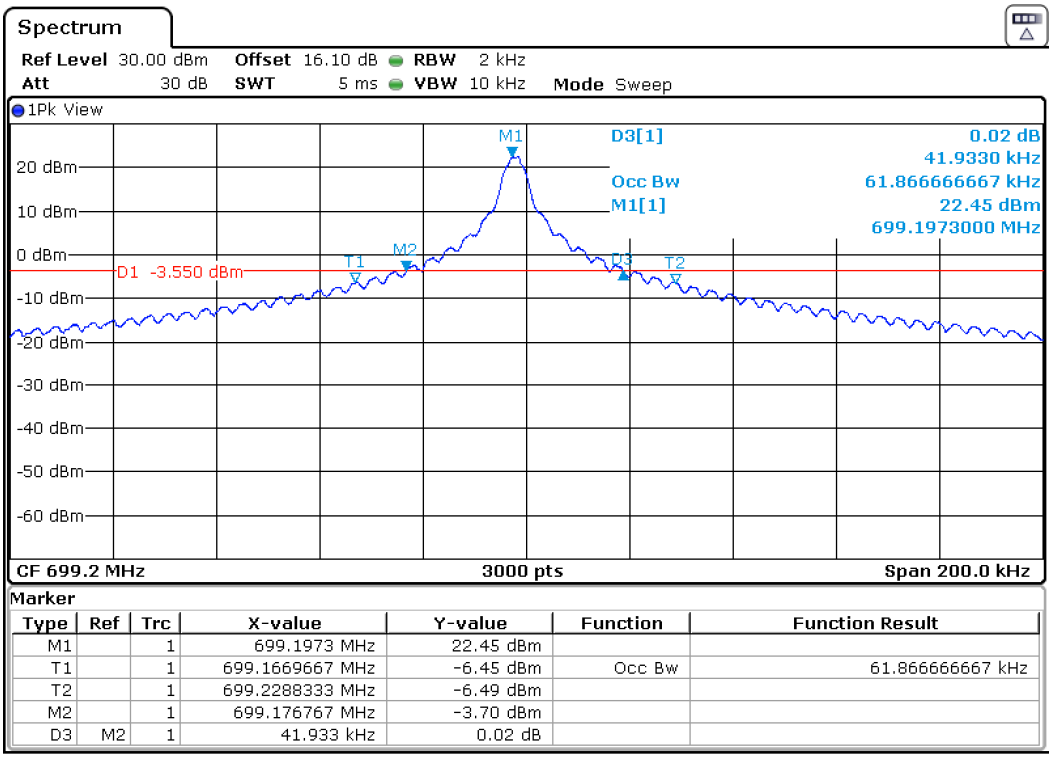



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 715.7969 MHz | 21.96 dBm | | |
| T1 | | 1 | 715.7692333 MHz | -6.74 dBm | Occ Bw | 57.866666667 kHz |
| T2 | | 1 | 715.8271 MHz | -9.14 dBm | | |
| M2 | | 1 | 715.776633 MHz | -4.08 dBm | | |
| D3 | M2 | 1 | 41.467 kHz | -0.01 dB | | |

Tone 3.75 kHz. π/4 - QPSK MODULATION

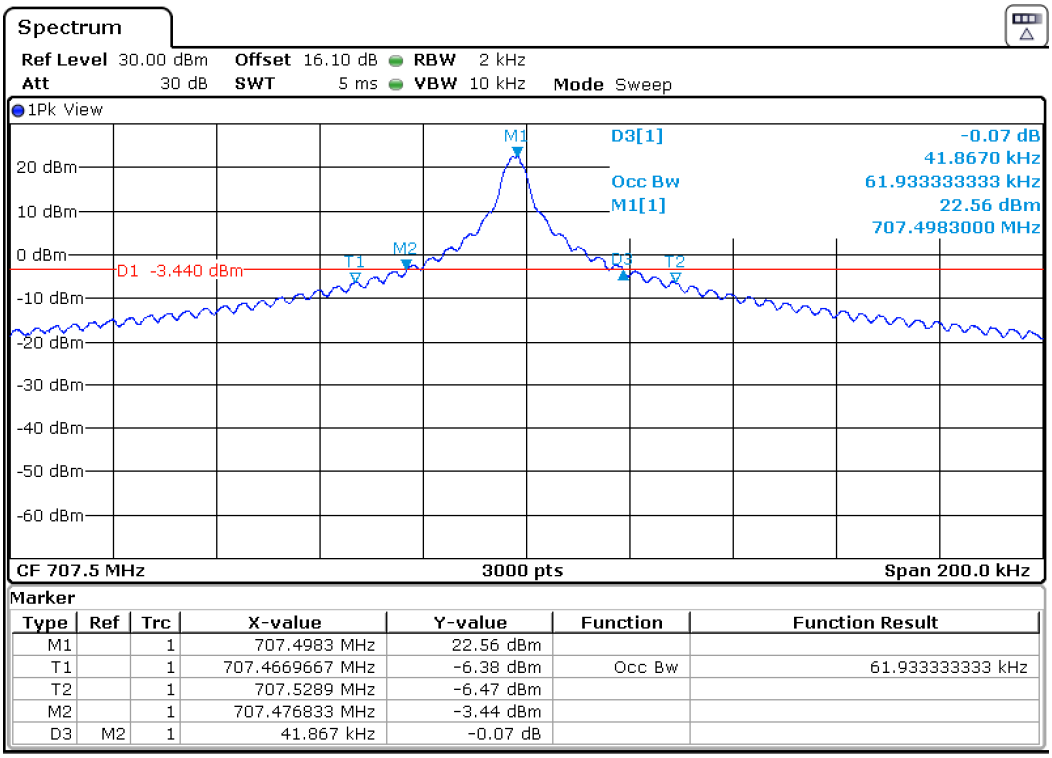
Lowest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 699.1973 MHz | 22.45 dBm | | |
| T1 | | 1 | 699.1669667 MHz | -6.45 dBm | Occ Bw | 61.866666667 kHz |
| T2 | | 1 | 699.2288333 MHz | -6.49 dBm | | |
| M2 | | 1 | 699.176767 MHz | -3.70 dBm | | |
| D3 | M2 | 1 | 41.933 kHz | 0.02 dB | | |

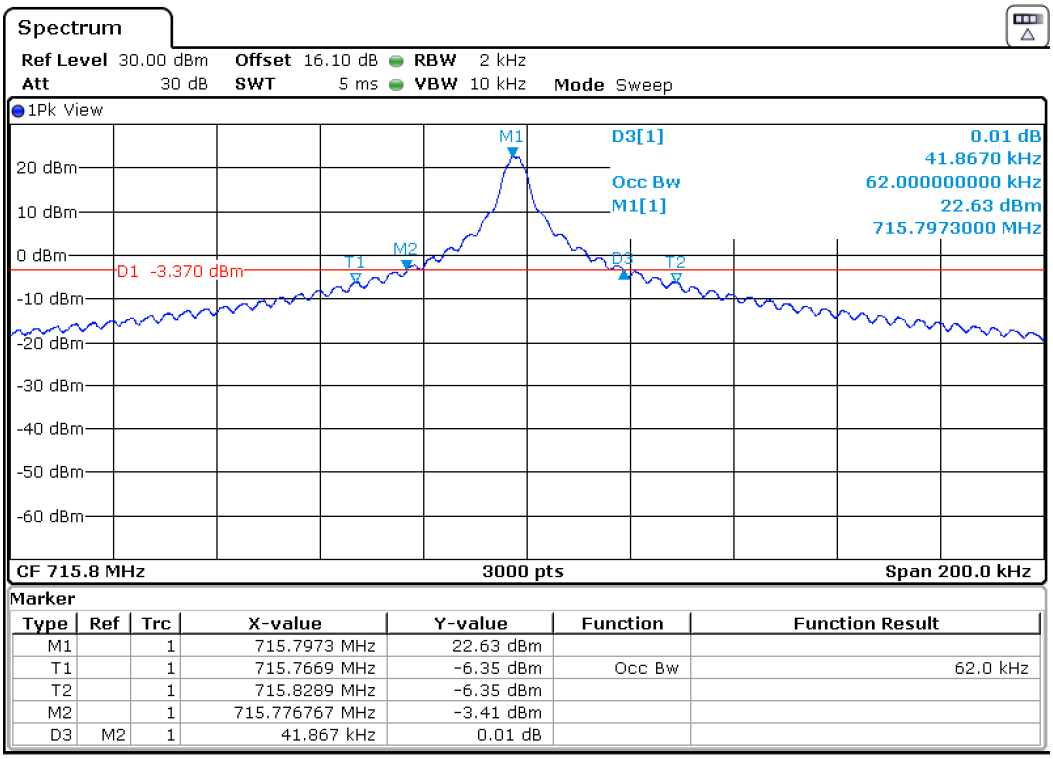
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 707.4983 MHz | 22.56 dBm | | |
| T1 | | 1 | 707.4669667 MHz | -6.38 dBm | Occ Bw | 61.933333333 kHz |
| T2 | | 1 | 707.5289 MHz | -6.47 dBm | | |
| M2 | | 1 | 707.476833 MHz | -3.44 dBm | | |
| D3 | M2 | 1 | 41.867 kHz | -0.07 dB | | |

Highest Channel

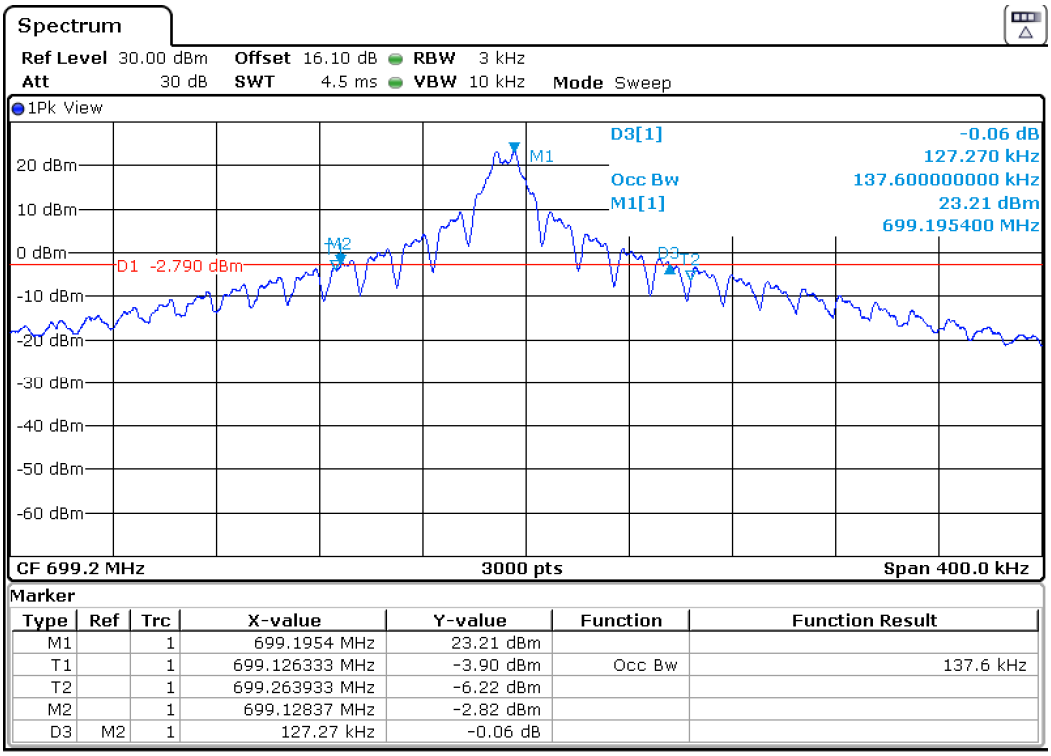



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 715.7973 MHz | 22.63 dBm | | |
| T1 | | 1 | 715.7669 MHz | -6.35 dBm | Occ Bw | 62.0 kHz |
| T2 | | 1 | 715.8289 MHz | -6.35 dBm | | |
| M2 | | 1 | 715.776767 MHz | -3.41 dBm | | |
| D3 | M2 | 1 | 41.867 kHz | 0.01 dB | | |

Tone 15 kHz. π/2 - BPSK MODULATION

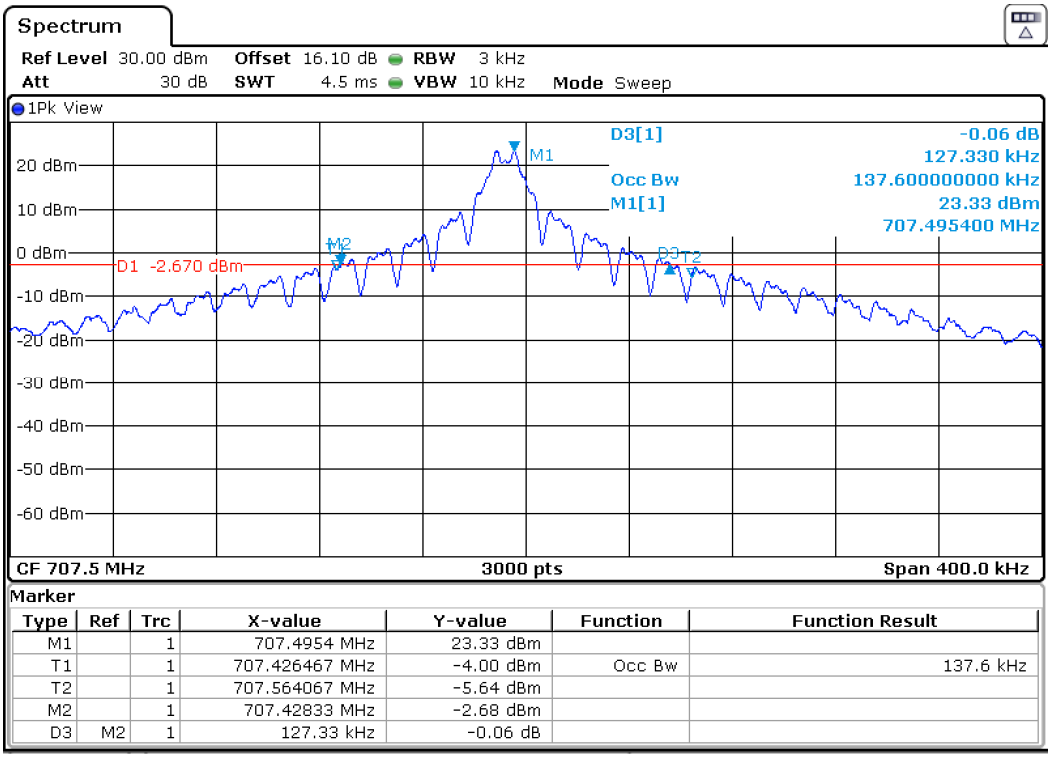
Lowest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 699.1954 MHz | 23.21 dBm | | |
| T1 | | 1 | 699.126333 MHz | -3.90 dBm | Occ Bw | 137.6 kHz |
| T2 | | 1 | 699.263933 MHz | -6.22 dBm | | |
| M2 | | 1 | 699.12837 MHz | -2.82 dBm | | |
| D3 | M2 | 1 | 127.27 kHz | -0.06 dB | | |

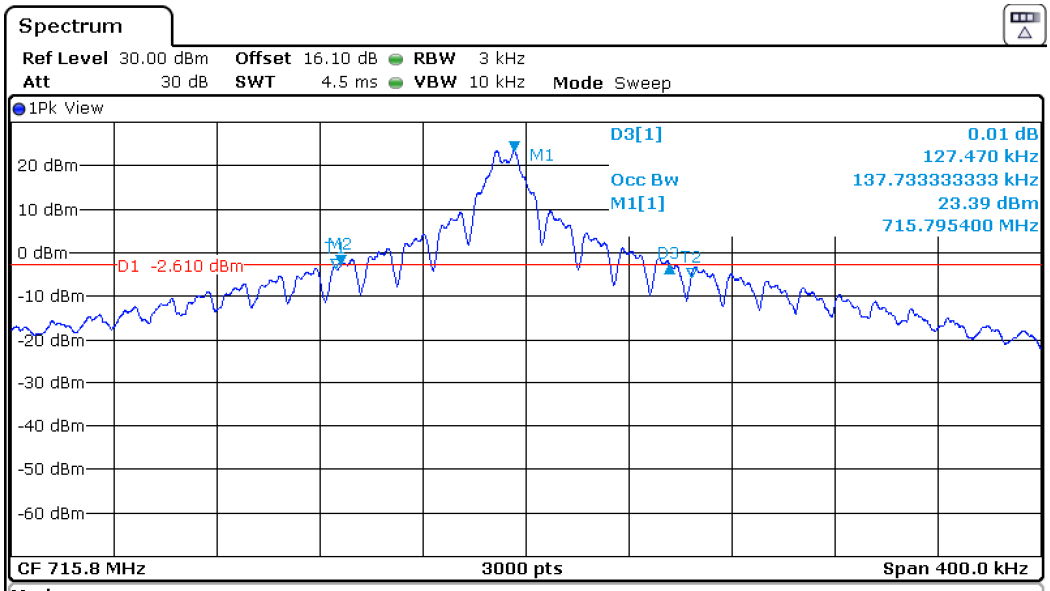
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 707.4954 MHz | 23.33 dBm | | |
| T1 | | 1 | 707.426467 MHz | -4.00 dBm | Occ Bw | 137.6 kHz |
| T2 | | 1 | 707.564067 MHz | -5.64 dBm | | |
| M2 | | 1 | 707.42833 MHz | -2.68 dBm | | |
| D3 | M2 | 1 | 127.33 kHz | -0.06 dB | | |

Highest Channel

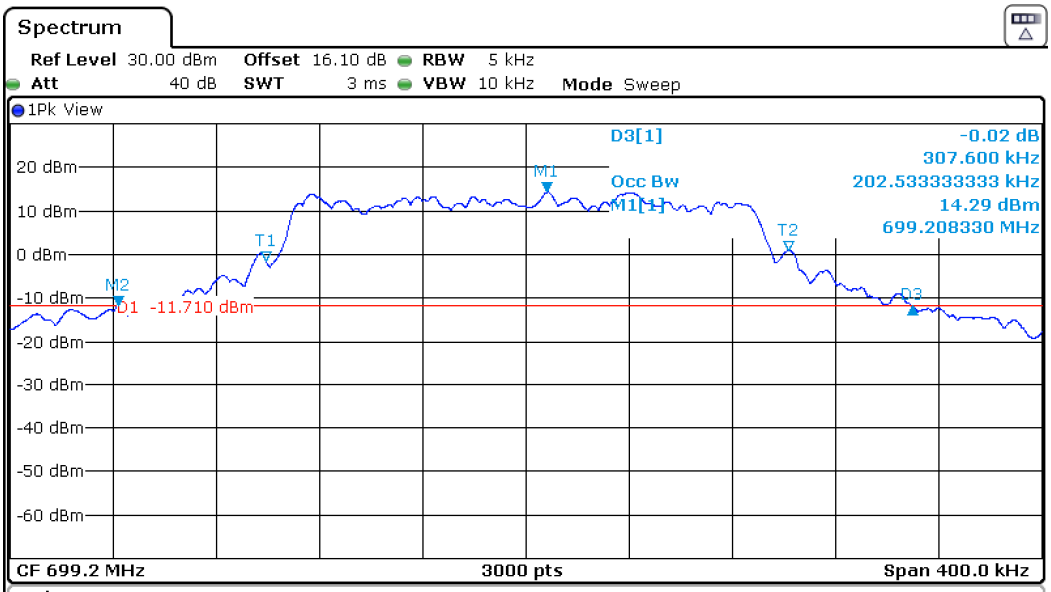



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 715.7954 MHz | 23.39 dBm | | |
| T1 | | 1 | 715.726333 MHz | -3.73 dBm | Occ Bw | 137.733333333 kHz |
| T2 | | 1 | 715.864067 MHz | -5.66 dBm | | |
| M2 | | 1 | 715.7282 MHz | -2.75 dBm | | |
| D3 | M2 | 1 | 127.47 kHz | 0.01 dB | | |

12 Tones 15 kHz. π/4 - QPSK MODULATION

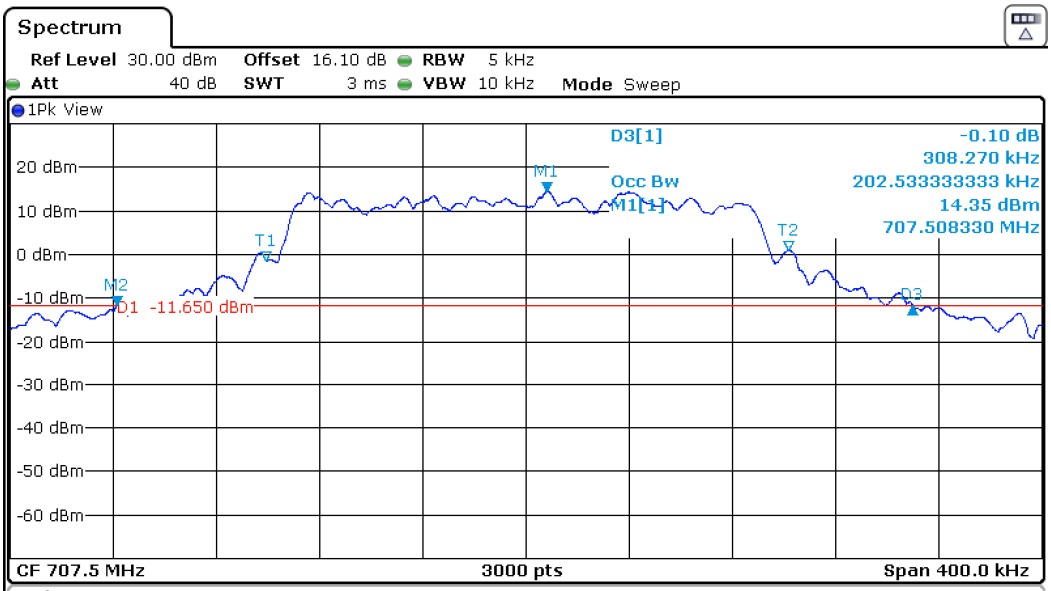
Lowest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 699.20833 MHz | 14.29 dBm | | |
| T1 | | 1 | 699.099267 MHz | -1.63 dBm | Occ Bw | 202.533333333 kHz |
| T2 | | 1 | 699.3018 MHz | 0.90 dBm | | |
| M2 | | 1 | 699.04207 MHz | -11.72 dBm | | |
| D3 | M2 | 1 | 307.6 kHz | -0.02 dB | | |

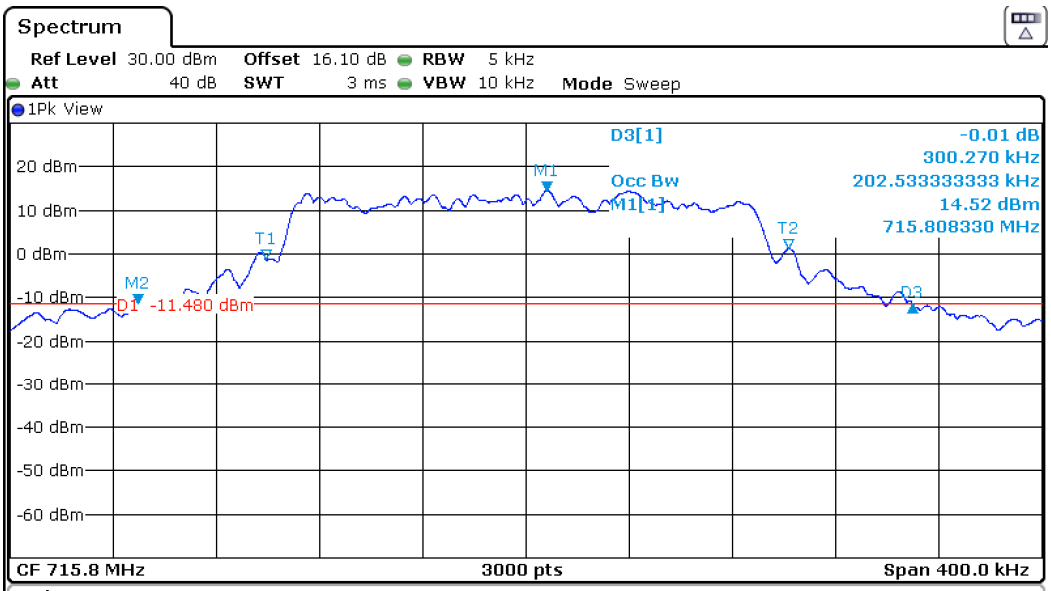
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 707.50833 MHz | 14.35 dBm | | |
| T1 | | 1 | 707.399267 MHz | -1.56 dBm | Occ Bw | 202.533333333 kHz |
| T2 | | 1 | 707.6018 MHz | 0.88 dBm | | |
| M2 | | 1 | 707.34167 MHz | -11.66 dBm | | |
| D3 | M2 | 1 | 308.27 kHz | -0.10 dB | | |

Highest Channel



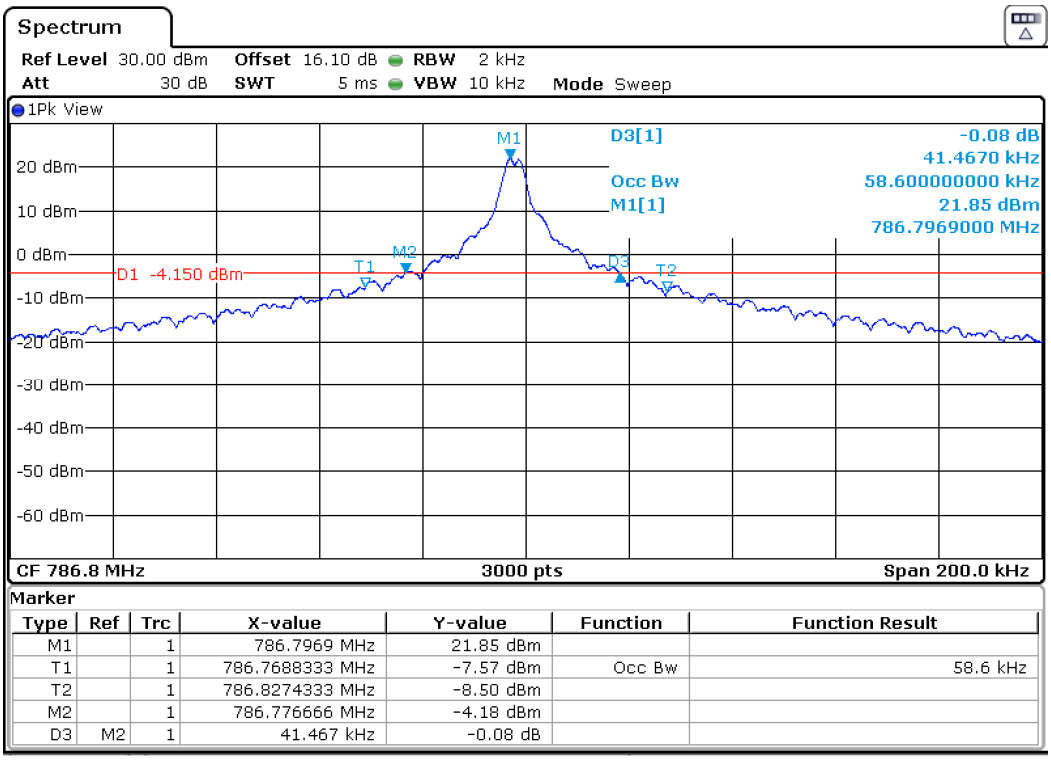

Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 715.80833 MHz | 14.52 dBm | | |
| T1 | | 1 | 715.699133 MHz | -1.28 dBm | Occ Bw | 202.533333333 kHz |
| T2 | | 1 | 715.901667 MHz | 1.08 dBm | | |
| M2 | | 1 | 715.64953 MHz | -11.57 dBm | | |
| D3 | M2 | 1 | 300.27 kHz | -0.01 dB | | |

NBIoT BAND 13.

Tone 3.75 kHz. π/2 - BPSK MODULATION

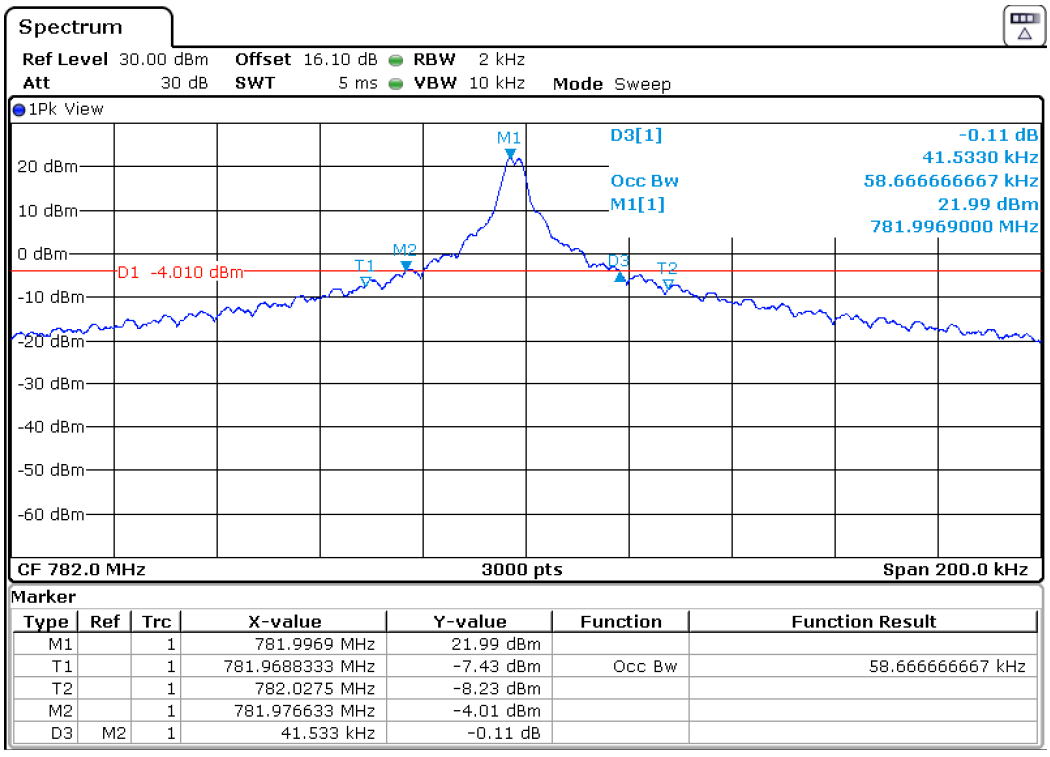
Lowest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 786.7969 MHz | 21.85 dBm | | |
| T1 | | 1 | 786.7688333 MHz | -7.57 dBm | Occ Bw | 58.6 kHz |
| T2 | | 1 | 786.8274333 MHz | -8.50 dBm | | |
| M2 | | 1 | 786.776666 MHz | -4.18 dBm | | |
| D3 | M2 | 1 | 41.467 kHz | -0.08 dB | | |

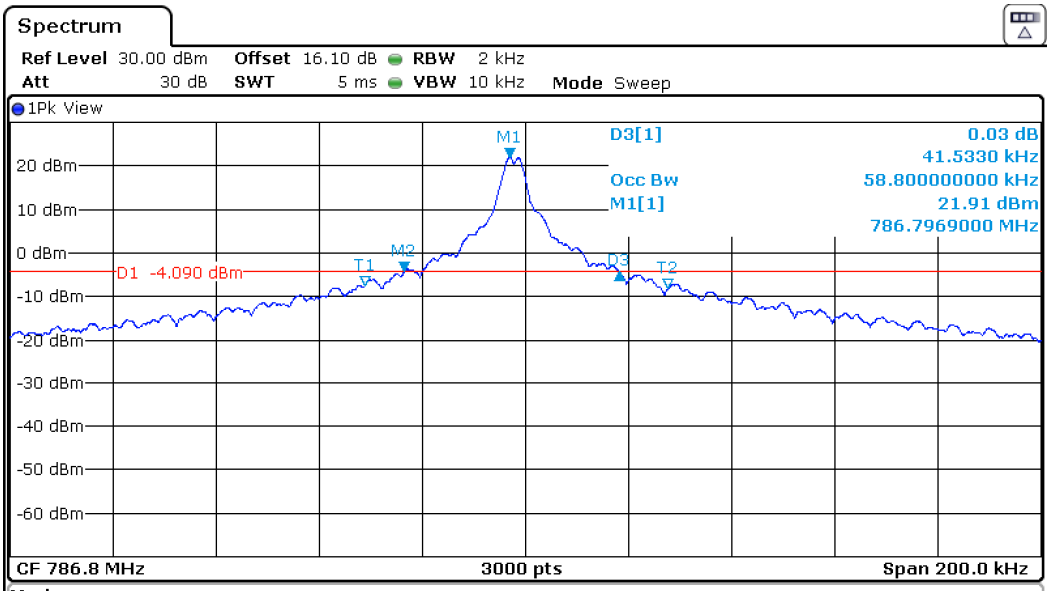
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 781.9969 MHz | 21.99 dBm | | |
| T1 | | 1 | 781.9688333 MHz | -7.43 dBm | Occ Bw | 58.666666667 kHz |
| T2 | | 1 | 782.0275 MHz | -8.23 dBm | | |
| M2 | | 1 | 781.976633 MHz | -4.01 dBm | | |
| D3 | M2 | 1 | 41.533 kHz | -0.11 dB | | |

Highest Channel

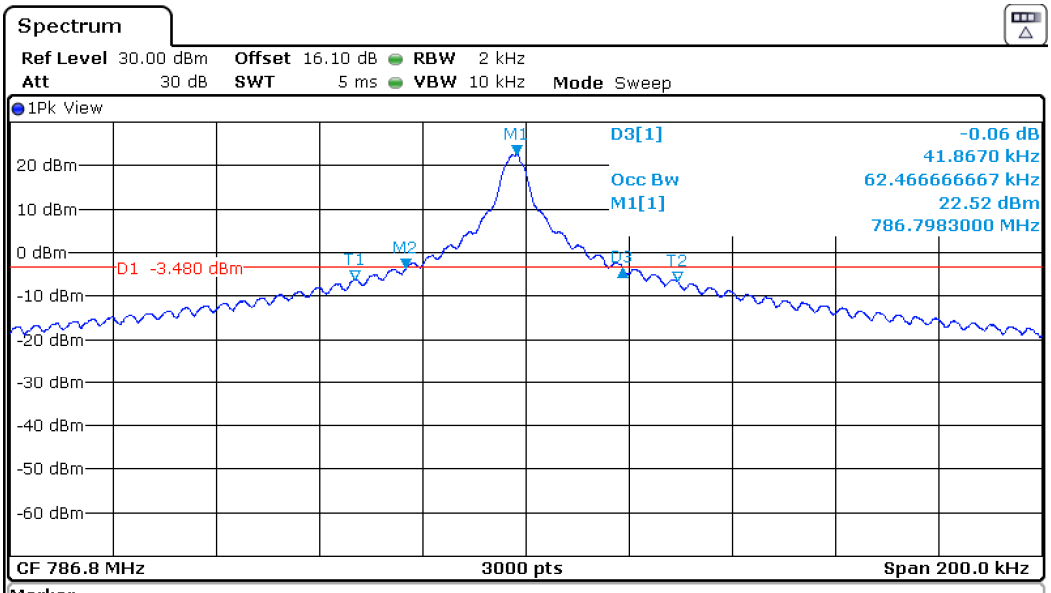



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 786.7969 MHz | 21.91 dBm | | |
| T1 | | 1 | 786.7687667 MHz | -7.63 dBm | Occ Bw | 58.8 kHz |
| T2 | | 1 | 786.8275667 MHz | -8.28 dBm | | |
| M2 | | 1 | 786.776567 MHz | -4.17 dBm | | |
| D3 | M2 | 1 | 41.533 kHz | 0.03 dB | | |

Tone 3.75 kHz. π/4 - QPSK MODULATION

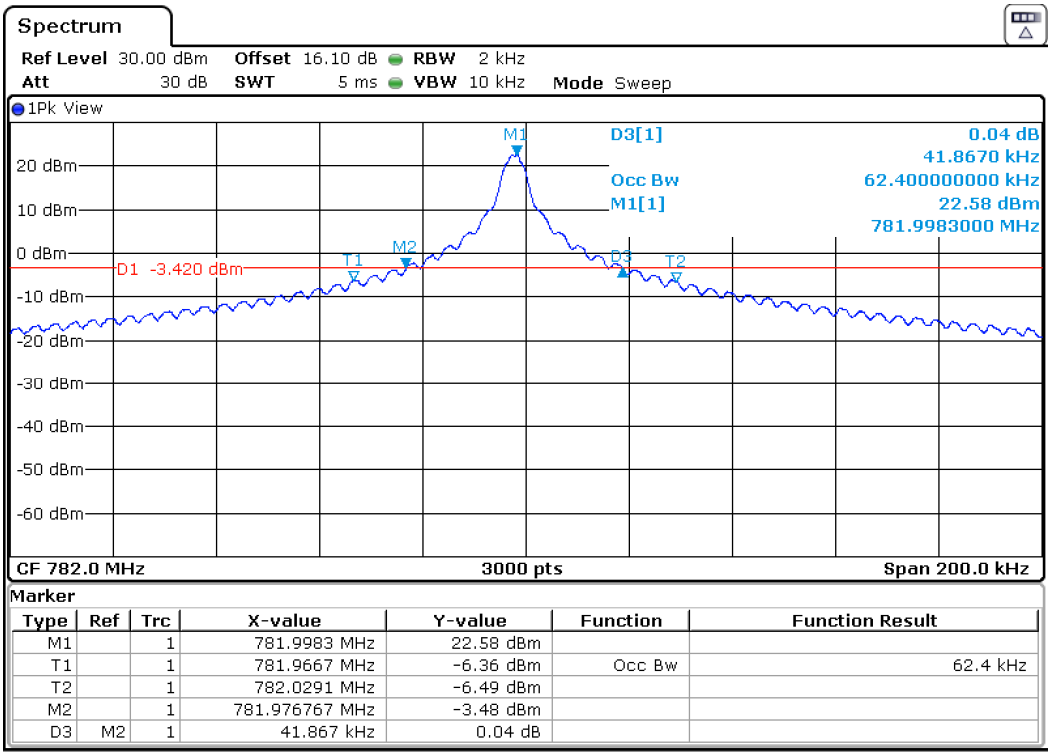
Lowest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 786.7983 MHz | 22.52 dBm | | |
| T1 | | 1 | 786.7667667 MHz | -6.36 dBm | Occ Bw | 62.466666667 kHz |
| T2 | | 1 | 786.8292333 MHz | -6.56 dBm | | |
| M2 | | 1 | 786.776799 MHz | -3.49 dBm | | |
| D3 | M2 | 1 | 41.867 kHz | -0.06 dB | | |

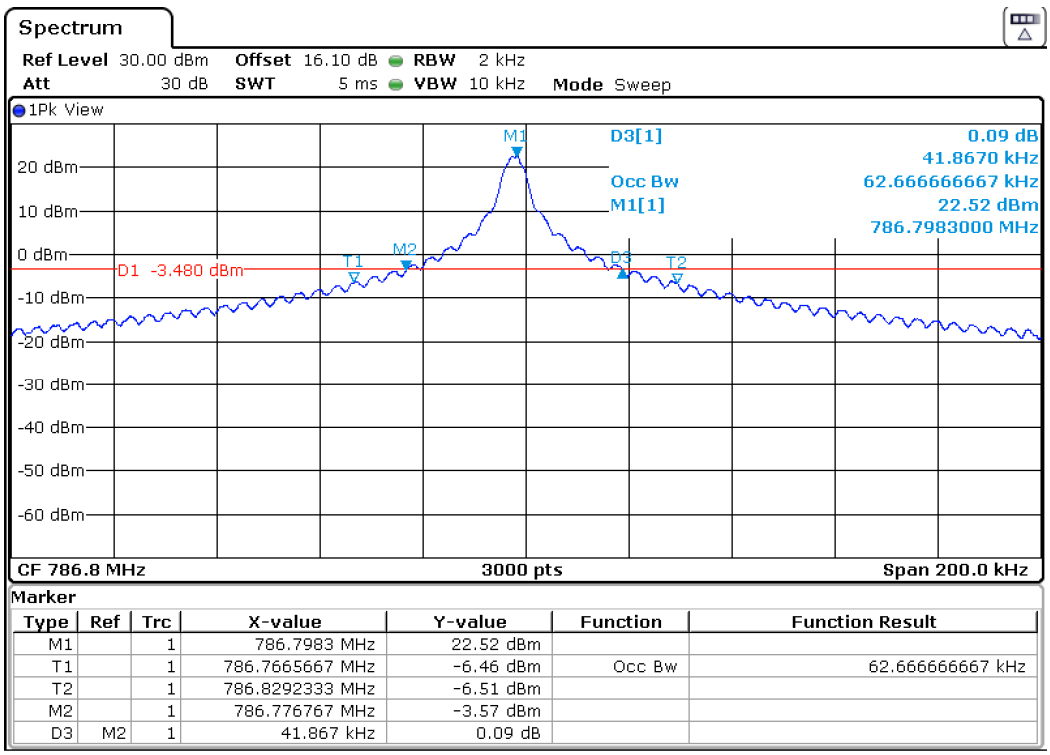
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 781.9983 MHz | 22.58 dBm | | |
| T1 | | 1 | 781.9667 MHz | -6.36 dBm | Occ Bw | 62.4 kHz |
| T2 | | 1 | 782.0291 MHz | -6.49 dBm | | |
| M2 | | 1 | 781.976767 MHz | -3.48 dBm | | |
| D3 | M2 | 1 | 41.867 kHz | 0.04 dB | | |

Highest Channel

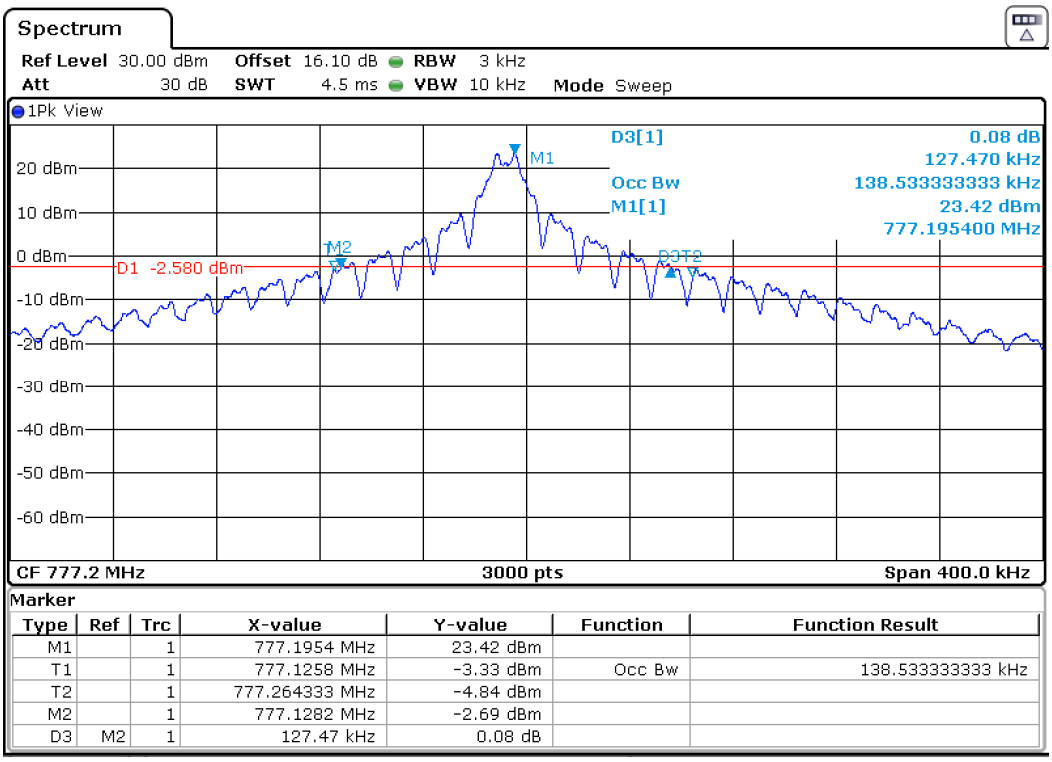



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 786.7983 MHz | 22.52 dBm | | |
| T1 | | 1 | 786.7665667 MHz | -6.46 dBm | Occ Bw | 62.666666667 kHz |
| T2 | | 1 | 786.8292333 MHz | -6.51 dBm | | |
| M2 | | 1 | 786.776767 MHz | -3.57 dBm | | |
| D3 | M2 | 1 | 41.867 kHz | 0.09 dB | | |

Tone 15 kHz. π/2 - BPSK MODULATION

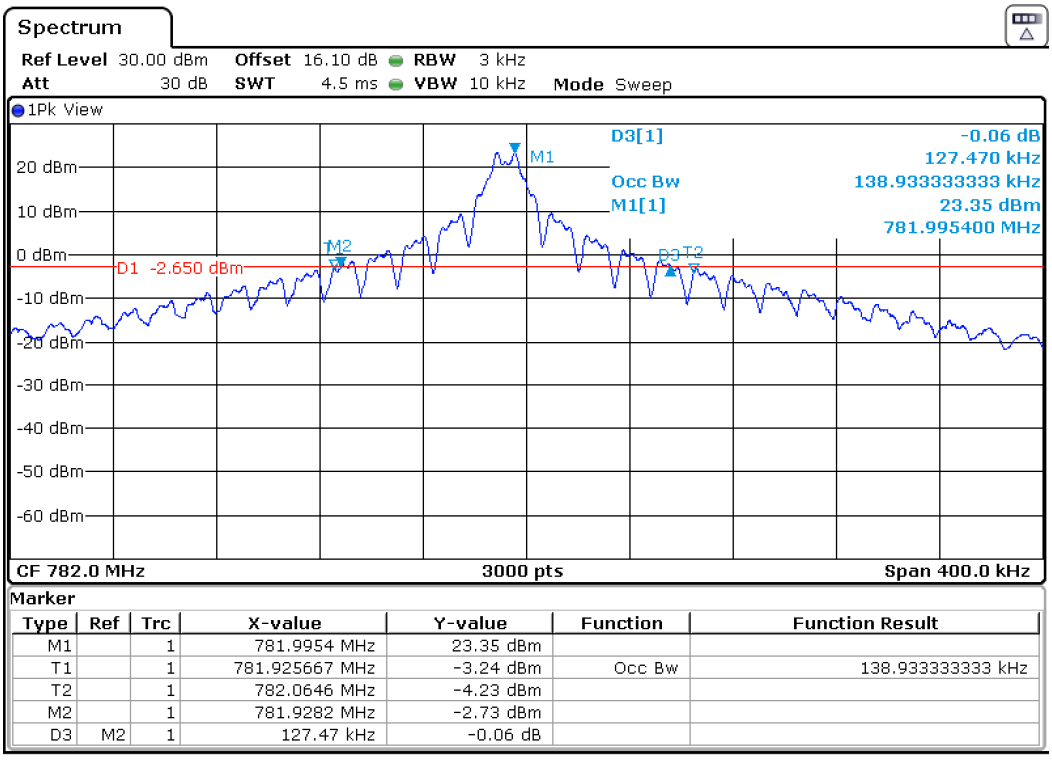
Lowest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 777.1954 MHz | 23.42 dBm | | |
| T1 | | 1 | 777.1258 MHz | -3.33 dBm | Occ Bw | 138.533333333 kHz |
| T2 | | 1 | 777.264333 MHz | -4.84 dBm | | |
| M2 | | 1 | 777.1282 MHz | -2.69 dBm | | |
| D3 | M2 | 1 | 127.47 kHz | 0.08 dB | | |

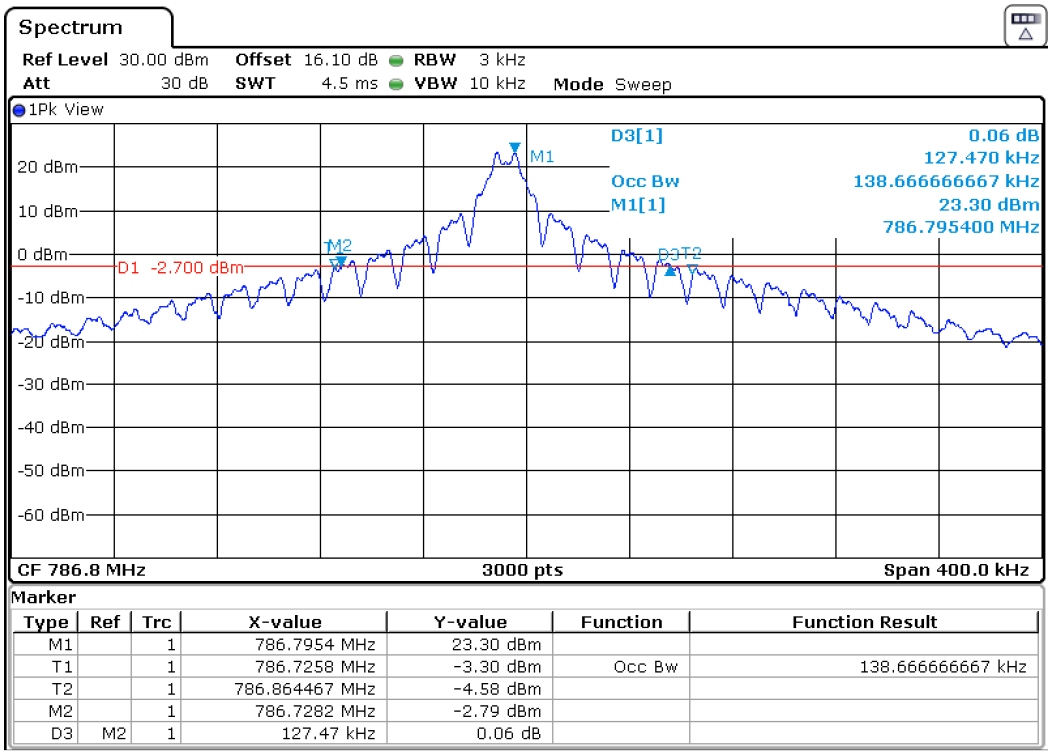
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 781.9954 MHz | 23.35 dBm | | |
| T1 | | 1 | 781.925667 MHz | -3.24 dBm | Occ Bw | 138.933333333 kHz |
| T2 | | 1 | 782.0646 MHz | -4.23 dBm | | |
| M2 | | 1 | 781.9282 MHz | -2.73 dBm | | |
| D3 | M2 | 1 | 127.47 kHz | -0.06 dB | | |

Highest Channel

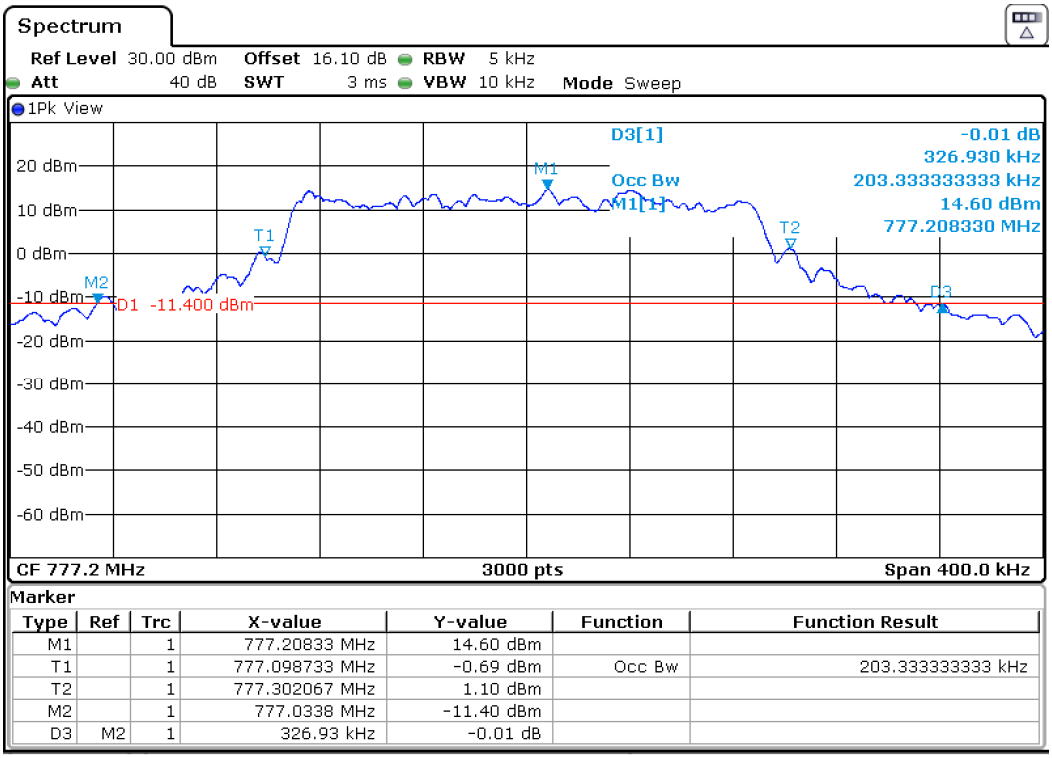



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 786.7954 MHz | 23.30 dBm | | |
| T1 | | 1 | 786.7258 MHz | -3.30 dBm | Occ Bw | 138.666666667 kHz |
| T2 | | 1 | 786.864467 MHz | -4.58 dBm | | |
| M2 | | 1 | 786.7282 MHz | -2.79 dBm | | |
| D3 | M2 | 1 | 127.47 kHz | 0.06 dB | | |

12 Tones 15 kHz. π/4 - QPSK MODULATION

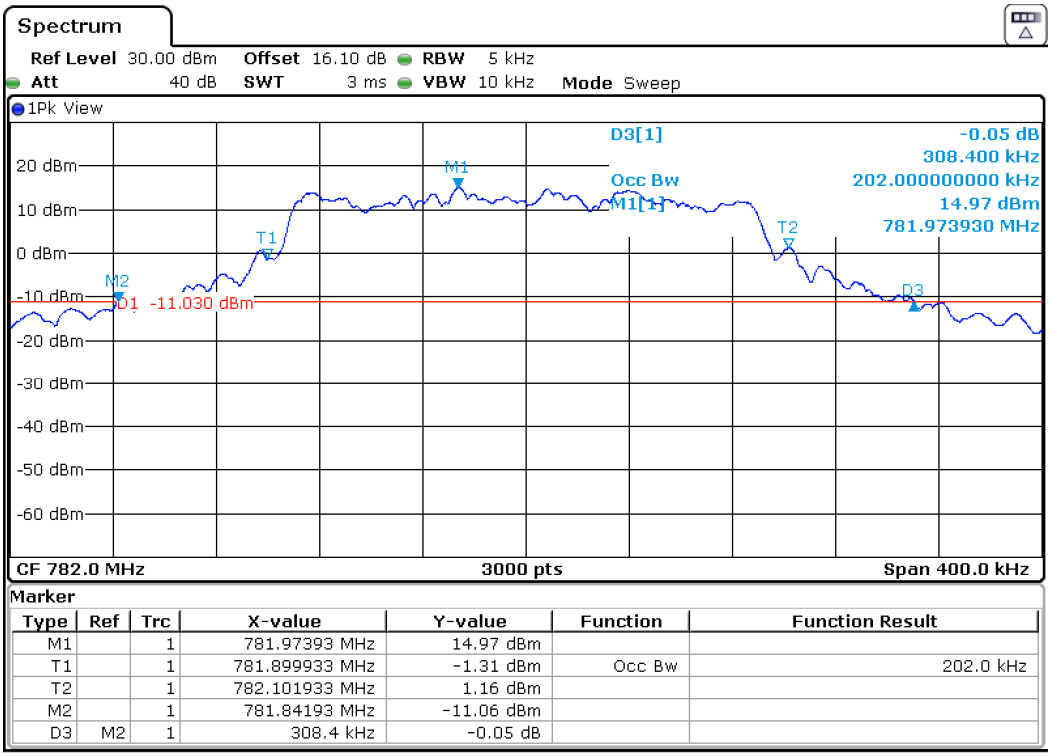
Lowest Channel




Marker

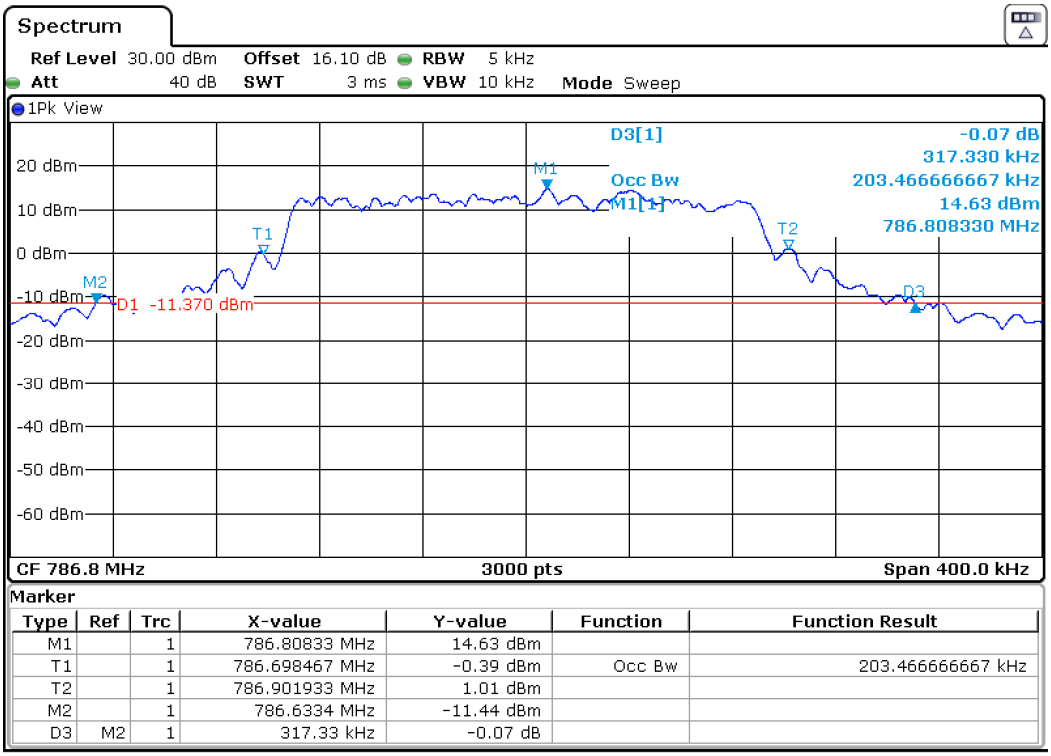
| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 777.20833 MHz | 14.60 dBm | | |
| T1 | | 1 | 777.098733 MHz | -0.69 dBm | Occ Bw | 203.333333333 kHz |
| T2 | | 1 | 777.302067 MHz | 1.10 dBm | | |
| M2 | | 1 | 777.0338 MHz | -11.40 dBm | | |
| D3 | M2 | 1 | 326.93 kHz | -0.01 dB | | |

Middle Channel




| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 781.97393 MHz | 14.97 dBm | | |
| T1 | | 1 | 781.899933 MHz | -1.31 dBm | Occ Bw | 202.0 kHz |
| T2 | | 1 | 782.101933 MHz | 1.16 dBm | | |
| M2 | | 1 | 781.84193 MHz | -11.06 dBm | | |
| D3 | M2 | 1 | 308.4 kHz | -0.05 dB | | |

Highest Channel

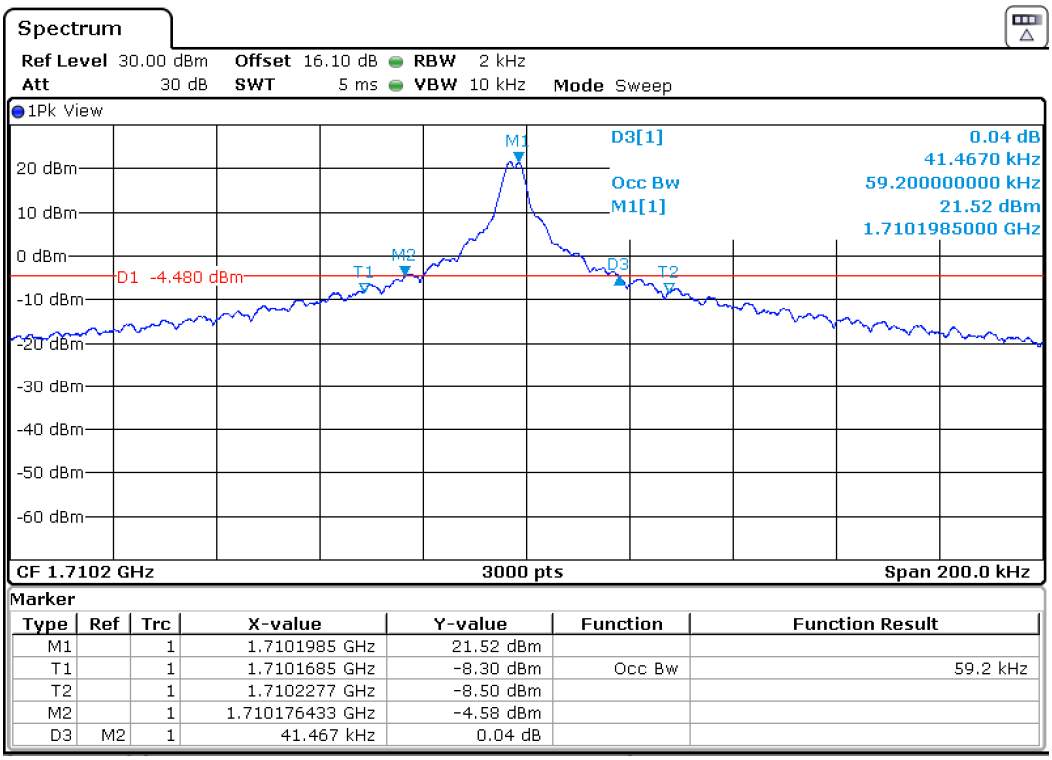



| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 786.80833 MHz | 14.63 dBm | | |
| T1 | | 1 | 786.698467 MHz | -0.39 dBm | Occ Bw | 203.466666667 kHz |
| T2 | | 1 | 786.901933 MHz | 1.01 dBm | | |
| M2 | | 1 | 786.6334 MHz | -11.44 dBm | | |
| D3 | M2 | 1 | 317.33 kHz | -0.07 dB | | |

NBIoT BAND 66.

Tone 3.75 kHz. π/2 - BPSK MODULATION

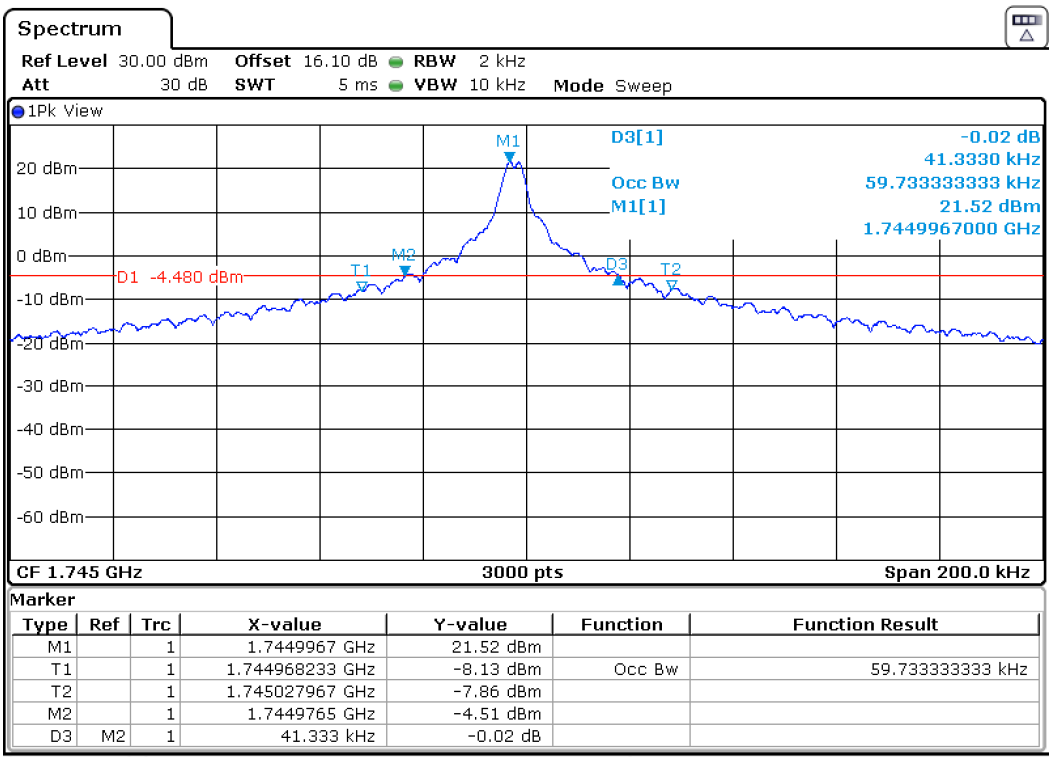
Lowest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.7101985 GHz | 21.52 dBm | | |
| T1 | | 1 | 1.7101685 GHz | -8.30 dBm | Occ Bw | 59.2 kHz |
| T2 | | 1 | 1.7102277 GHz | -8.50 dBm | | |
| M2 | | 1 | 1.710176433 GHz | -4.58 dBm | | |
| D3 | M2 | 1 | 41.467 kHz | 0.04 dB | | |

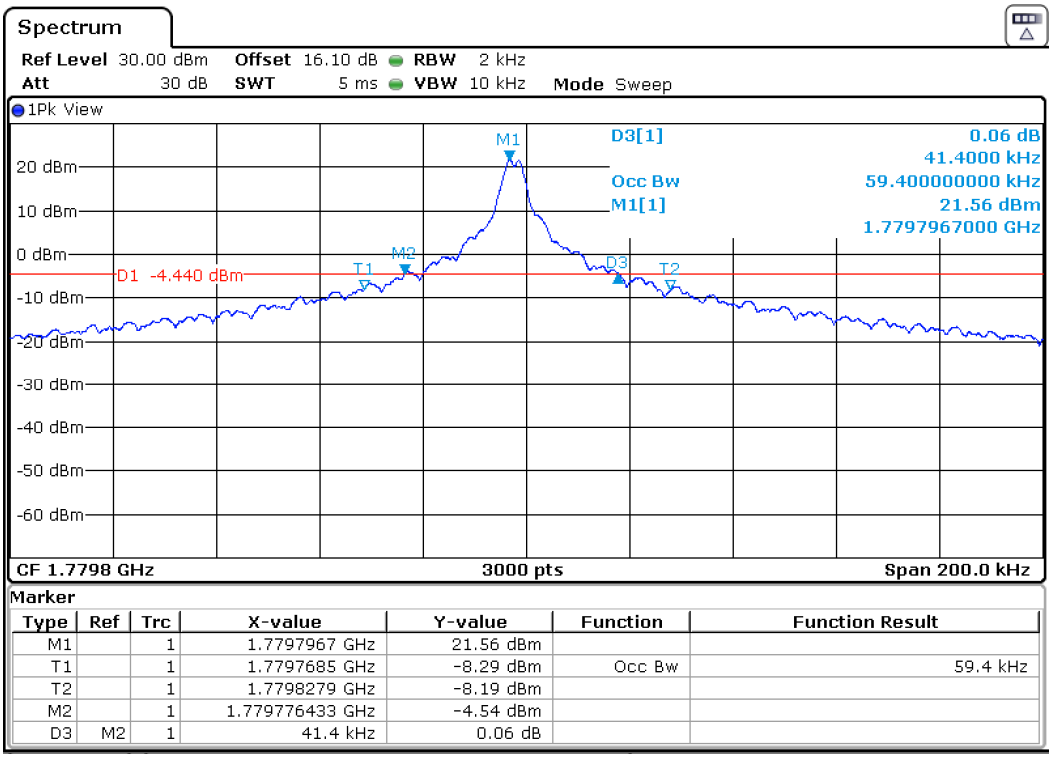
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.7449967 GHz | 21.52 dBm | | |
| T1 | | 1 | 1.744968233 GHz | -8.13 dBm | Occ Bw | 59.733333333 kHz |
| T2 | | 1 | 1.745027967 GHz | -7.86 dBm | | |
| M2 | | 1 | 1.7449765 GHz | -4.51 dBm | | |
| D3 | M2 | 1 | 41.333 kHz | -0.02 dB | | |

Highest Channel

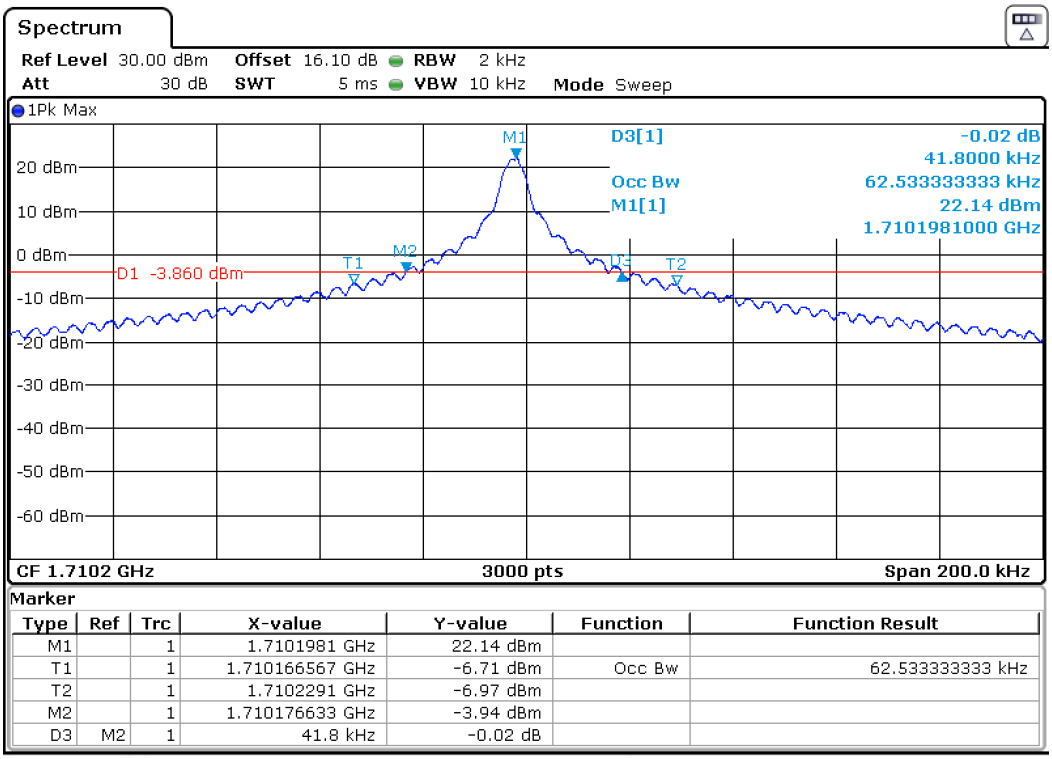



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.7797967 GHz | 21.56 dBm | | |
| T1 | | 1 | 1.7797685 GHz | -8.29 dBm | Occ Bw | 59.4 kHz |
| T2 | | 1 | 1.7798279 GHz | -8.19 dBm | | |
| M2 | | 1 | 1.779776433 GHz | -4.54 dBm | | |
| D3 | M2 | 1 | 41.4 kHz | 0.06 dB | | |

Tone 3.75 kHz. π/4 - QPSK MODULATION

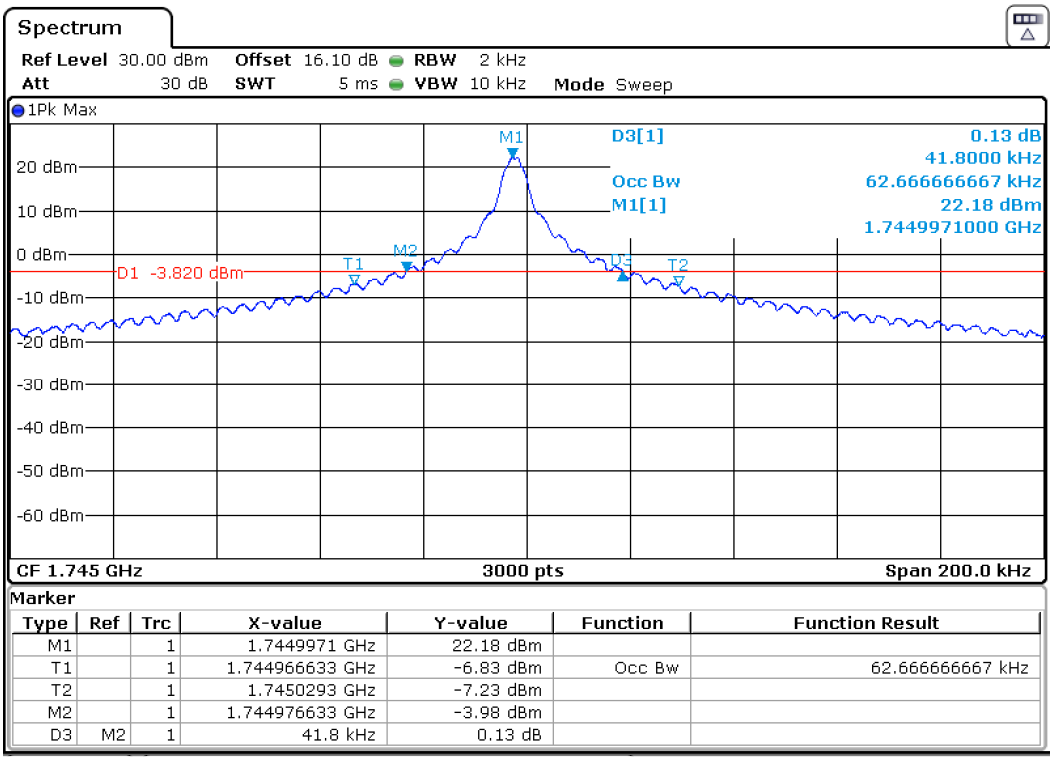
Lowest Channel



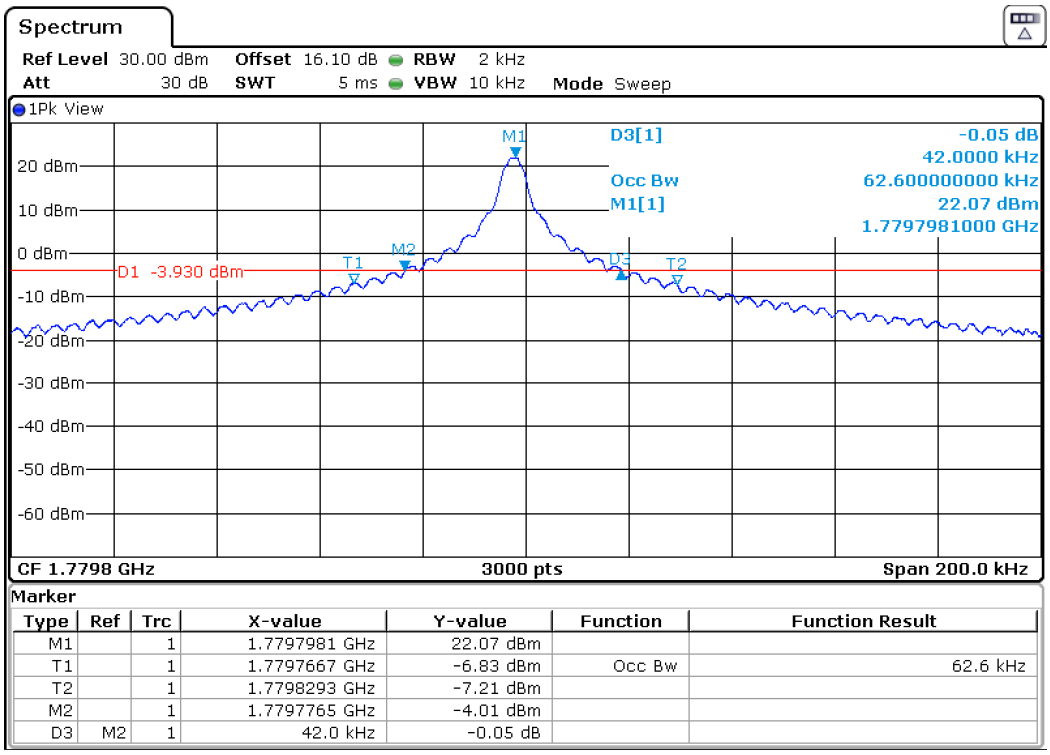

Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.7101981 GHz | 22.14 dBm | | |
| T1 | | 1 | 1.710166567 GHz | -6.71 dBm | Occ Bw | 62.533333333 kHz |
| T2 | | 1 | 1.7102291 GHz | -6.97 dBm | | |
| M2 | | 1 | 1.710176633 GHz | -3.94 dBm | | |
| D3 | M2 | 1 | 41.8 kHz | -0.02 dB | | |

Middle Channel

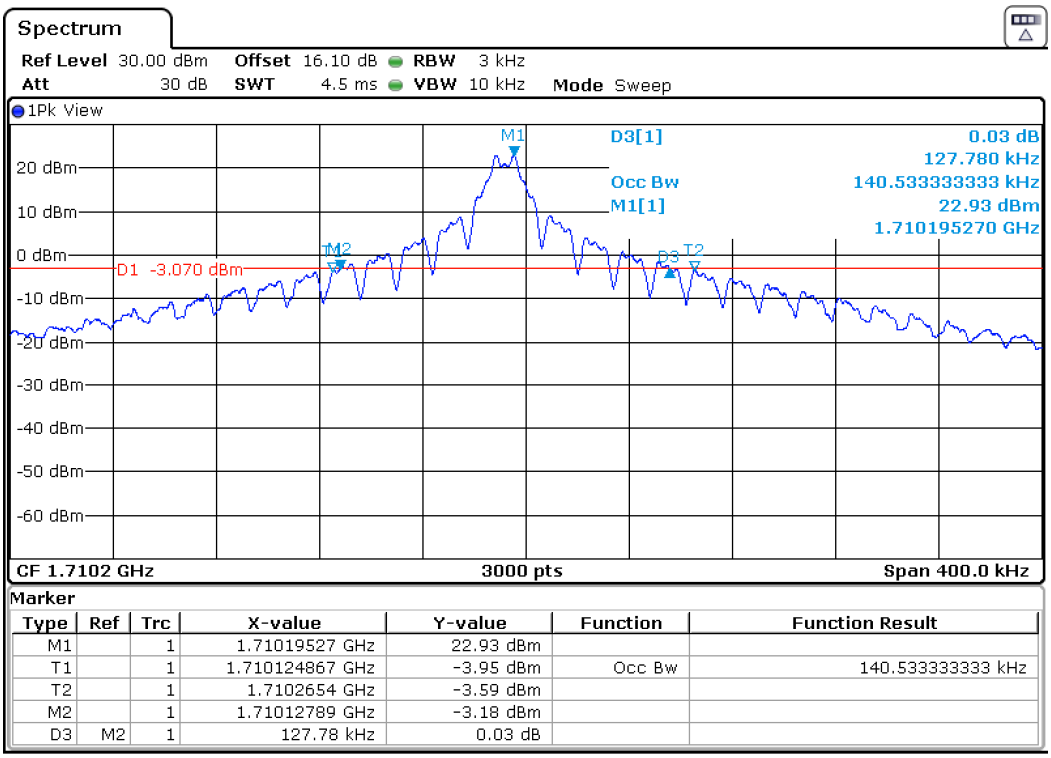



Highest Channel



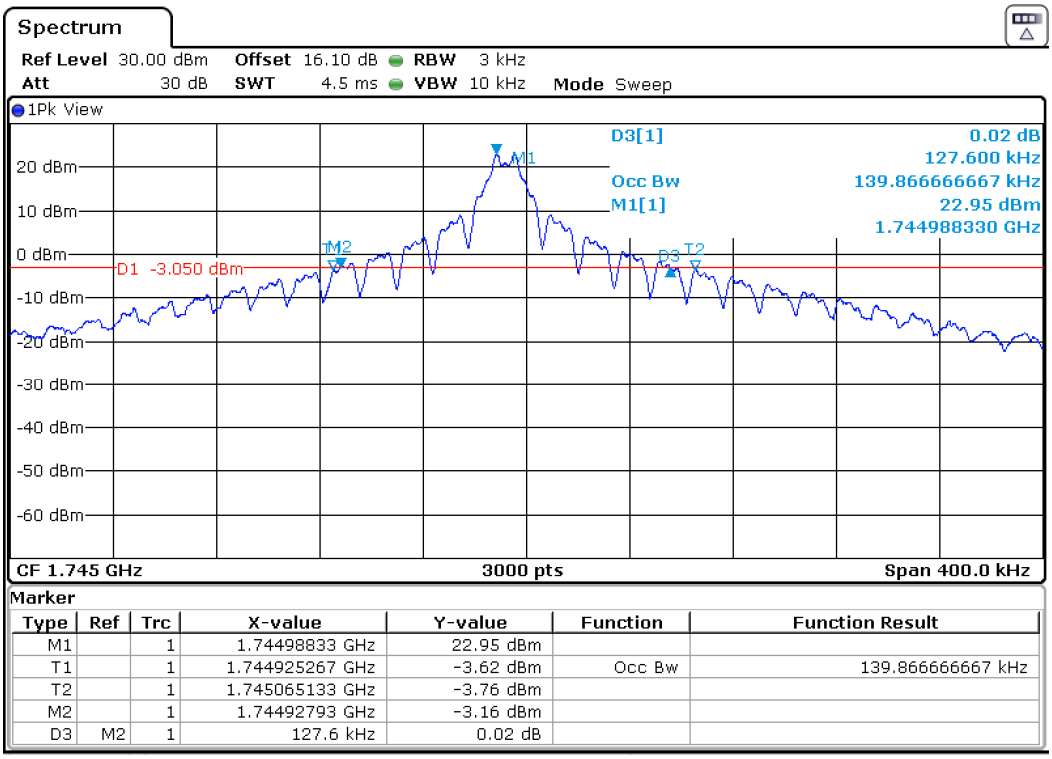
Tone 15 kHz. π/2 - BPSK MODULATION

Lowest Channel



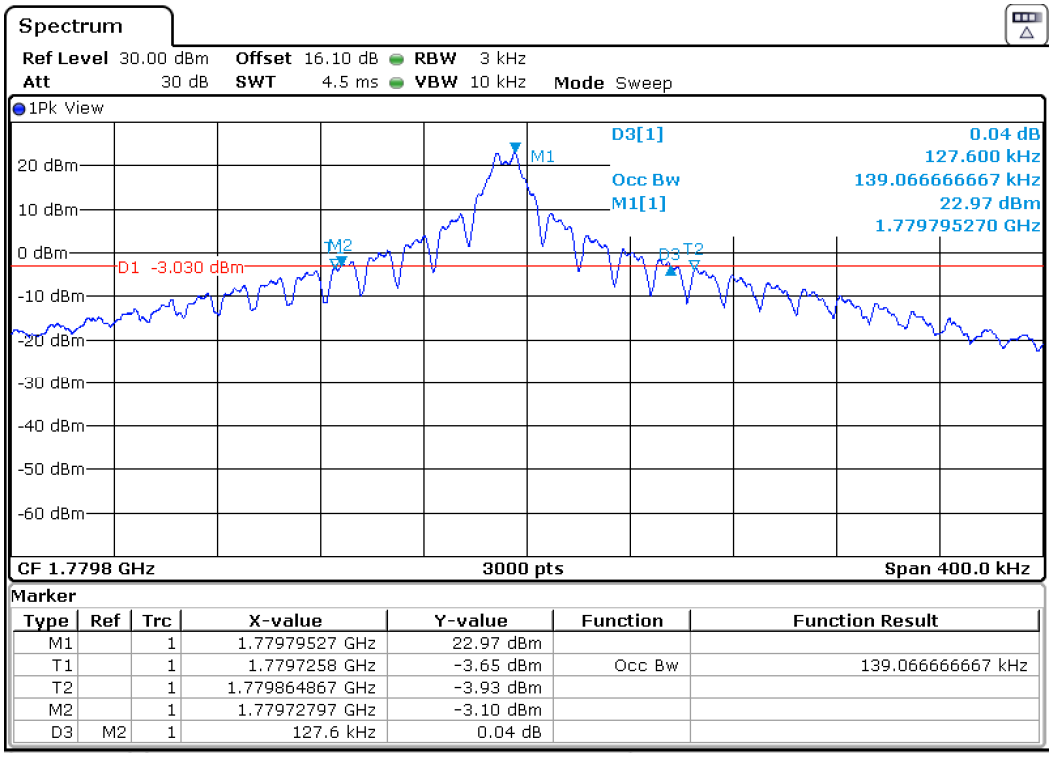

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.71019527 GHz | 22.93 dBm | | |
| T1 | | 1 | 1.710124867 GHz | -3.95 dBm | Occ Bw | 140.533333333 kHz |
| T2 | | 1 | 1.7102654 GHz | -3.59 dBm | | |
| M2 | | 1 | 1.71012789 GHz | -3.18 dBm | | |
| D3 | M2 | 1 | 127.78 kHz | 0.03 dB | | |

Middle Channel




| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.74498833 GHz | 22.95 dBm | | |
| T1 | | 1 | 1.744925267 GHz | -3.62 dBm | Occ Bw | 139.866666667 kHz |
| T2 | | 1 | 1.745065133 GHz | -3.76 dBm | | |
| M2 | | 1 | 1.74492793 GHz | -3.16 dBm | | |
| D3 | M2 | 1 | 127.6 kHz | 0.02 dB | | |

Highest Channel

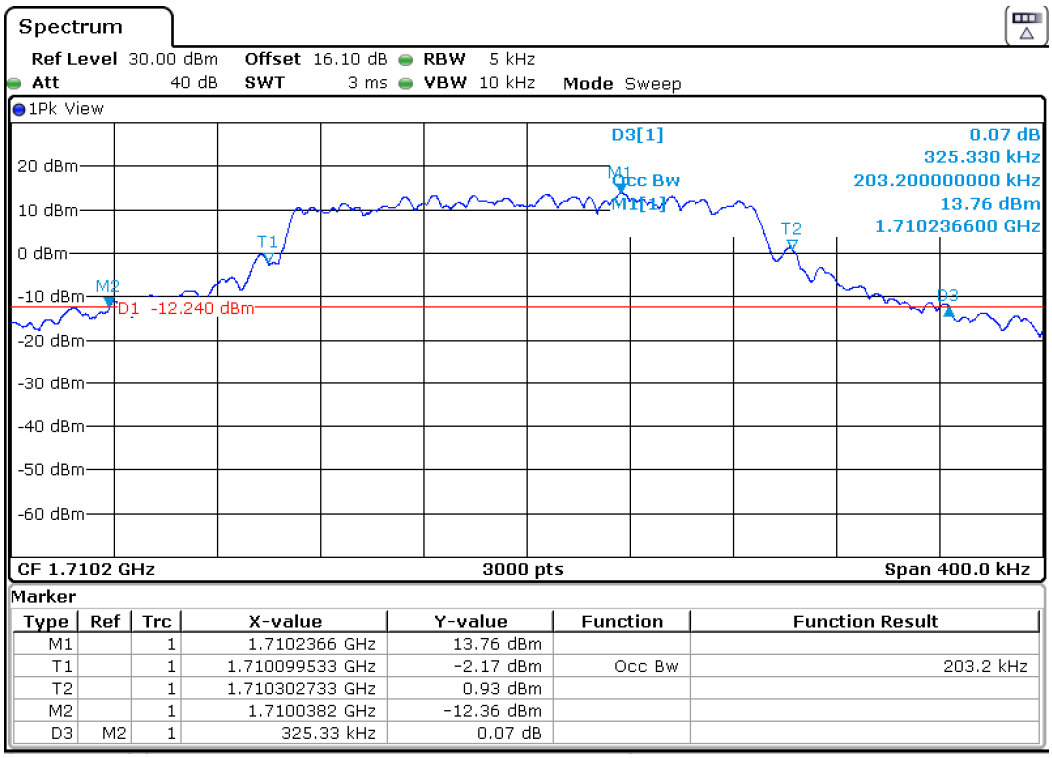



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.77979527 GHz | 22.97 dBm | | |
| T1 | | 1 | 1.7797258 GHz | -3.65 dBm | Occ Bw | 139.066666667 kHz |
| T2 | | 1 | 1.779864867 GHz | -3.93 dBm | | |
| M2 | | 1 | 1.77972797 GHz | -3.10 dBm | | |
| D3 | M2 | 1 | 127.6 kHz | 0.04 dB | | |

12 Tones 15 kHz. π/4 - QPSK MODULATION

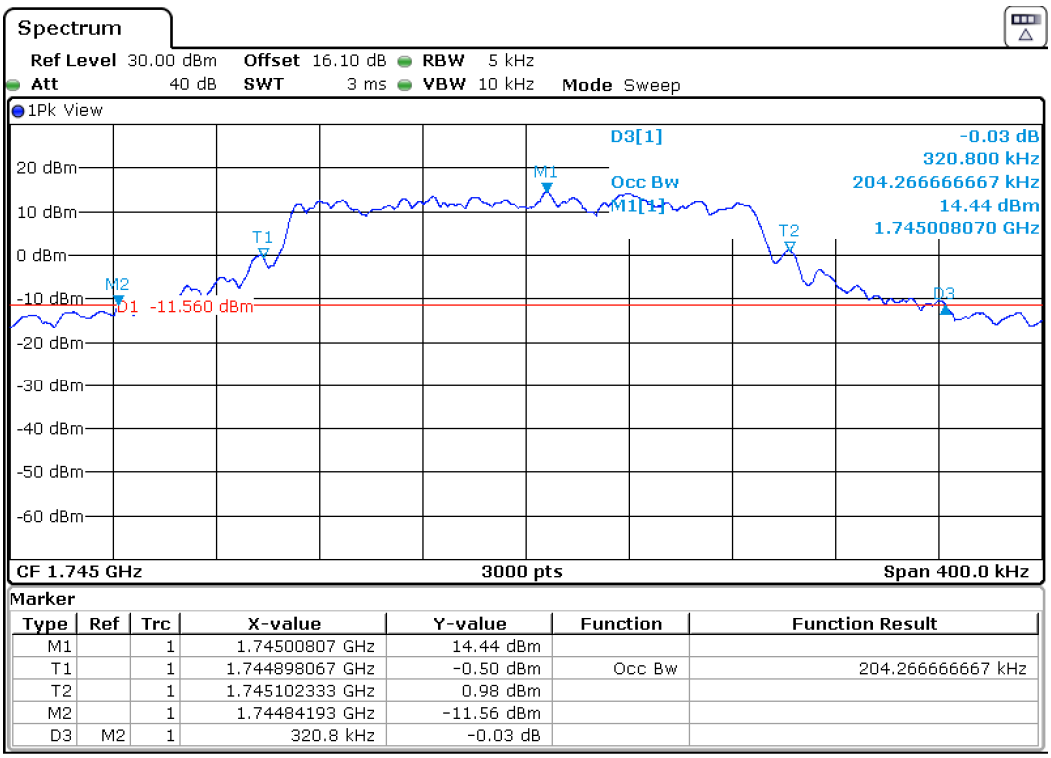
Lowest Channel




Marker

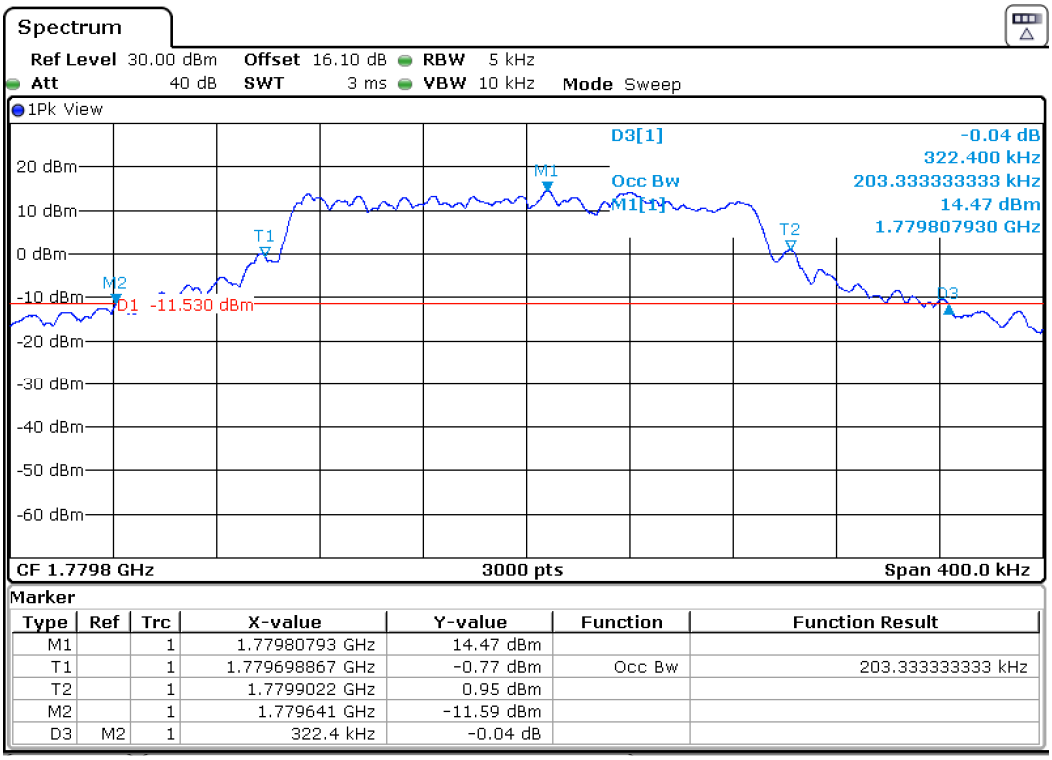
| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.7102366 GHz | 13.76 dBm | | |
| T1 | | 1 | 1.710099533 GHz | -2.17 dBm | Occ Bw | 203.2 kHz |
| T2 | | 1 | 1.710302733 GHz | 0.93 dBm | | |
| M2 | | 1 | 1.7100382 GHz | -12.36 dBm | | |
| D3 | M2 | 1 | 325.33 kHz | 0.07 dB | | |

Middle Channel




| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.74500807 GHz | 14.44 dBm | | |
| T1 | | 1 | 1.744898067 GHz | -0.50 dBm | Occ Bw | 204.266666667 kHz |
| T2 | | 1 | 1.745102333 GHz | 0.98 dBm | | |
| M2 | | 1 | 1.74484193 GHz | -11.56 dBm | | |
| D3 | M2 | 1 | 320.8 kHz | -0.03 dB | | |

Highest Channel




| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.77980793 GHz | 14.47 dBm | | |
| T1 | | 1 | 1.779698867 GHz | -0.77 dBm | Occ Bw | 203.333333333 kHz |
| T2 | | 1 | 1.7799022 GHz | 0.95 dBm | | |
| M2 | | 1 | 1.779641 GHz | -11.59 dBm | | |
| D3 | M2 | 1 | 322.4 kHz | -0.04 dB | | |

# Spurious emissions at antenna terminals

## SPECIFICATION

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. However. in the 100 kilohertz bands immediately outside and adjacent to a licensee's frequency block. a resolution bandwidth of at least 30 kHz may be employed

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.

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.

RSS-130 Clause 4.6.
The power of any unwanted emissions in any 100 kHz bandwidth on any frequency outside the frequency range(s) within which the equipment is designed to operate shall be attenuated below the transmitter power. P (dBW). by at least 43 + 10 log10 p (watts). dB.

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 65 + 10 log10 p(watts). dB. for mobile and portable equipment.

FCC §27.53 (h). RSS-139 Clause 6.6.

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

At Po transmitting power. the specified minimum attenuation becomes 43+10 log (Po). and the level in dBm relative Po becomes:
Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = -13 dBm.
At Po transmitting power. the specified minimum attenuation becomes 65+10 log (Po). and the level in dBm relative Po becomes:
Po (dBm) – [65 + 10 log (Po in mwatts) - 30] = -35 dBm.

## METHOD

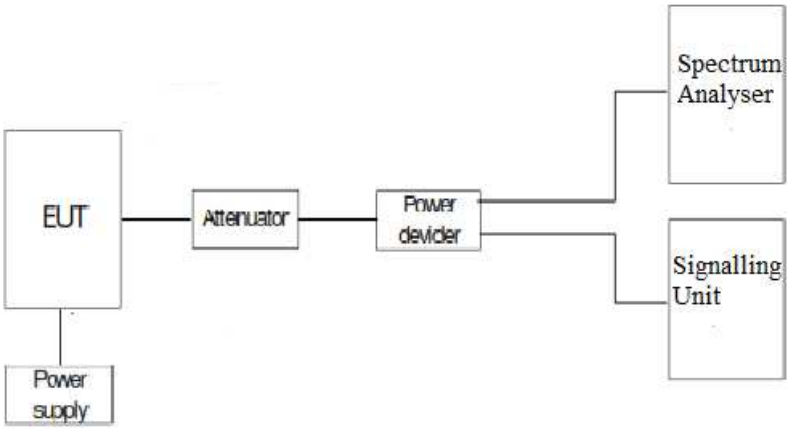
The EUT RF output connector was connected to a spectrum analyser and to the Universal Radio Communication tester R&S CMW500 (selecting maximum transmission power of the EUT and different modes of modulation) using a 50 ohm attenuator and a power divider.

The spectrum was investigated from 9 kHz to 18 GHz for NBIoT Band 66 and from 9 kHz to 8 GHz for NBIoT Band 12 and 13.

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 tones and modulation which is the worst case for conducted power was used.

TEST SETUP




RESULTS (see plots in next pages)

NBIoT Band 12

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.

NBIoT Band 13

1. CHANNEL: LOWEST

| Frequency (MHz) | Level (dBm) | Limit (dBm) |
|---|---|---|
| 765.0847 | -57.94 | -35.00 |
| 768.9319 | -52.85 | -35.00 |
| 771.0972 | -49.01 | -35.00 |
| 774.9048 | -51.84 | -35.00 |

2. CHANNEL: MIDDLE

| Frequency (MHz) | Level (dBm) | Limit (dBm) |
|---|---|---|
| 773.7298 | -52.86 | -35.00 |

3. CHANNEL: HIGHEST

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

NBIoT Band 66

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.

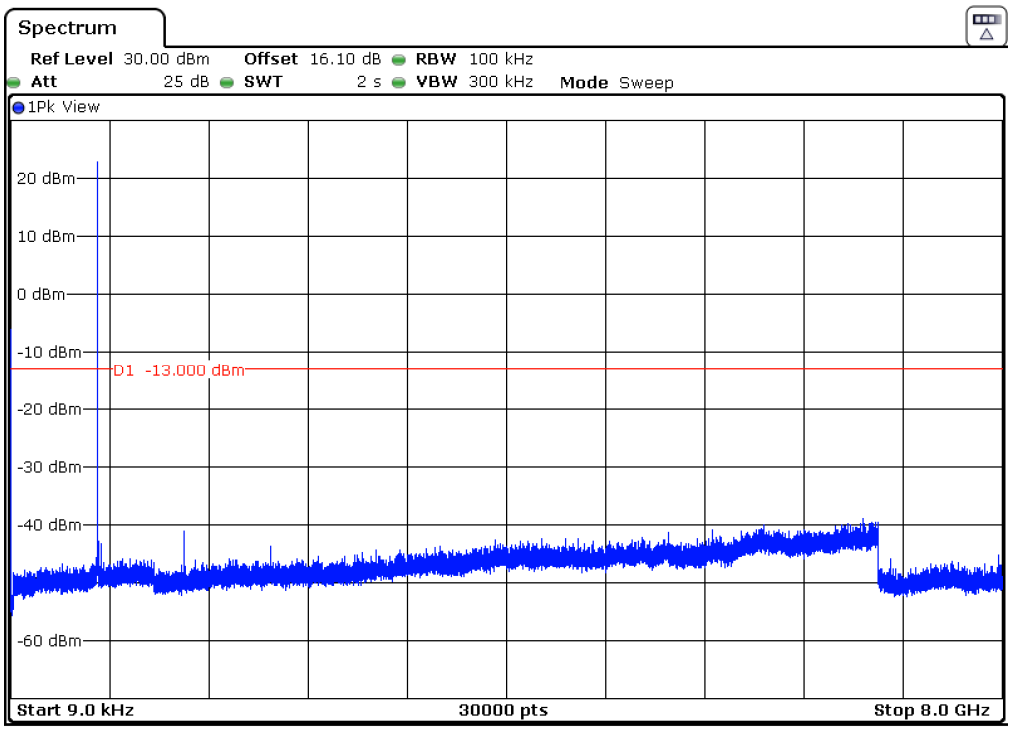
3. CHANNEL: HIGHEST
No spurious signals were found at less than 20dB respect to the limit in all the range.

Verdict: PASS

NBIoT Band 12

1. CHANNEL: LOWEST

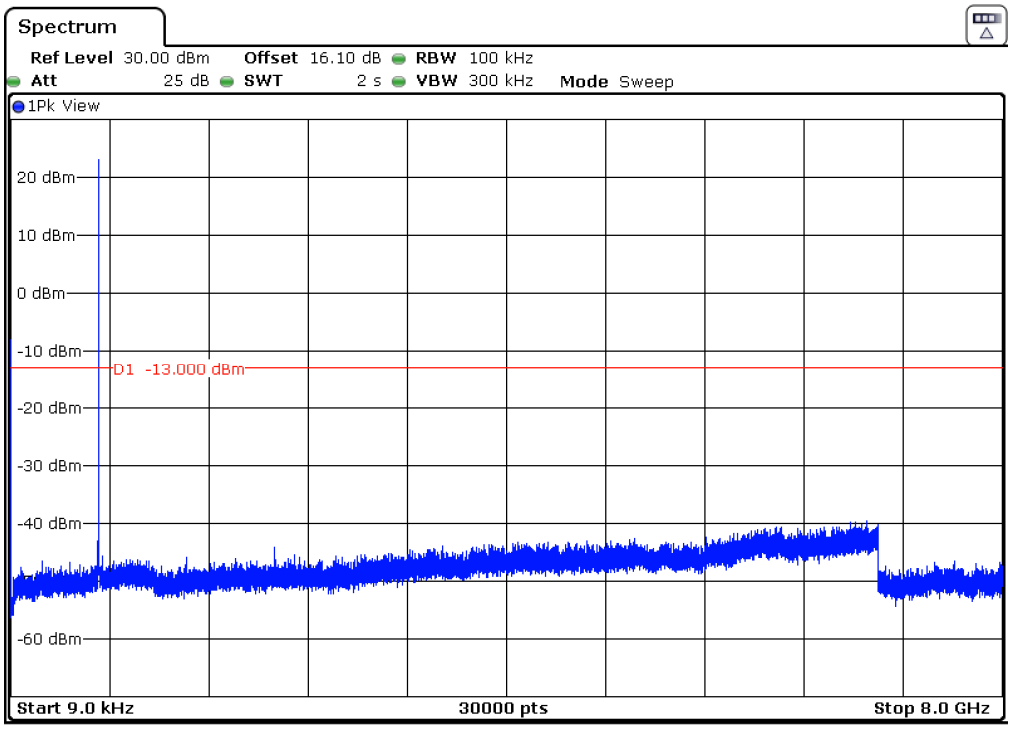
Frequency Range 9 kHz – 8 GHz




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

2. CHANNEL: MIDDLE

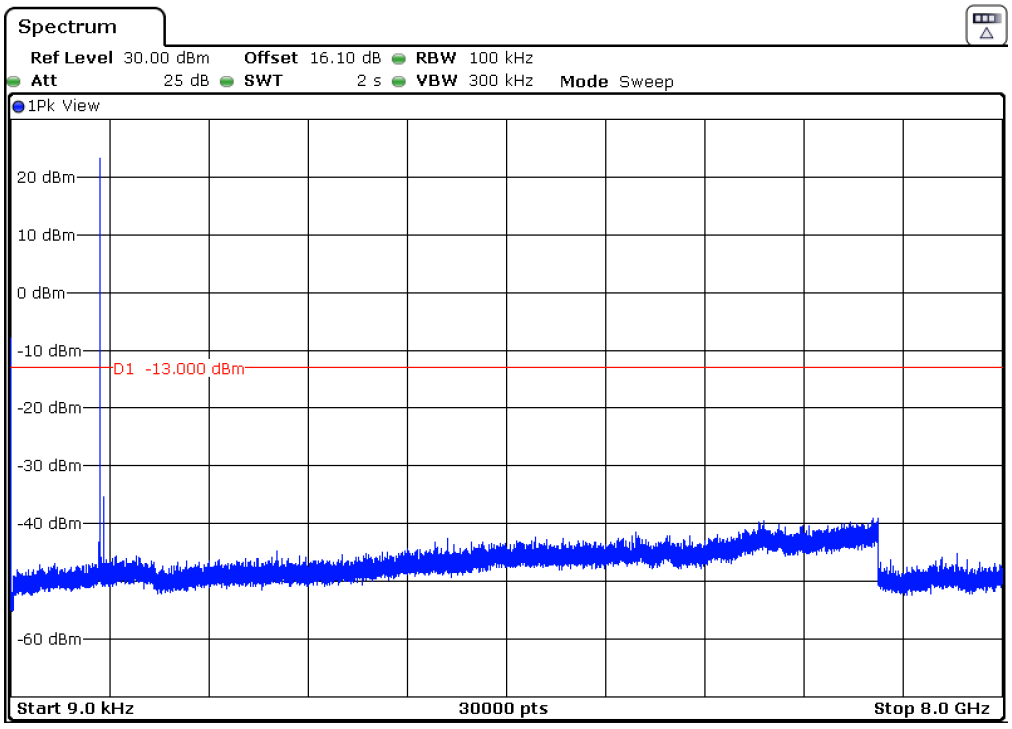
Frequency Range 9 kHz – 8 GHz




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

3. CHANNEL: HIGHEST

Frequency Range 9 kHz – 8 GHz

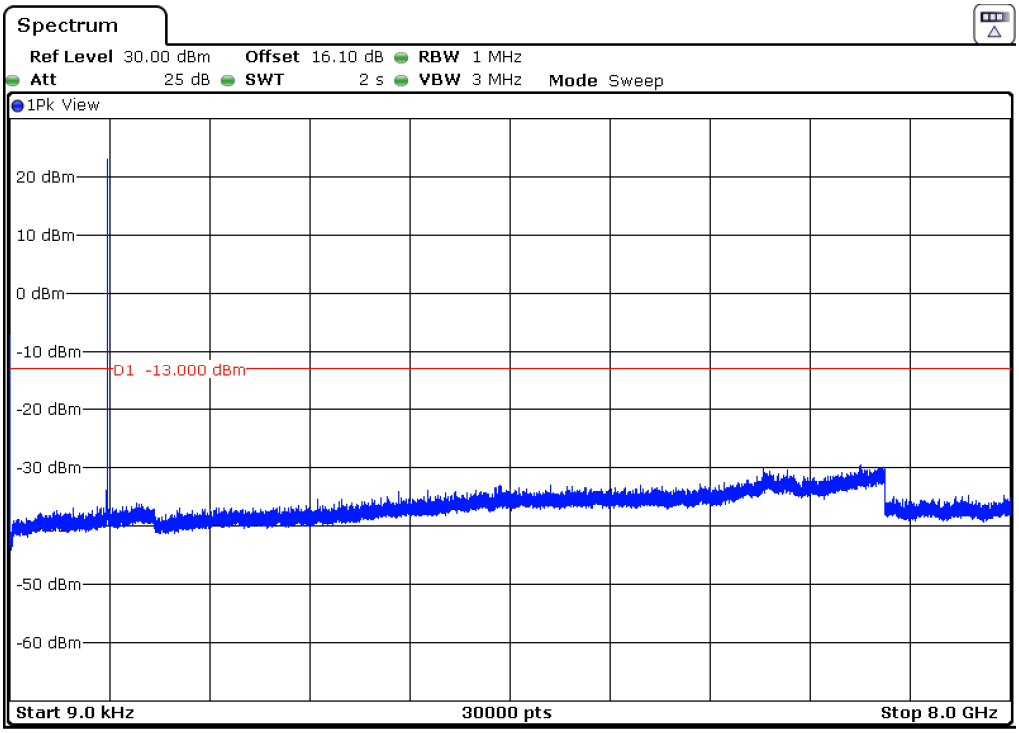



Note: The peak above the limit is the carrier frequency.

NBIoT Band 13

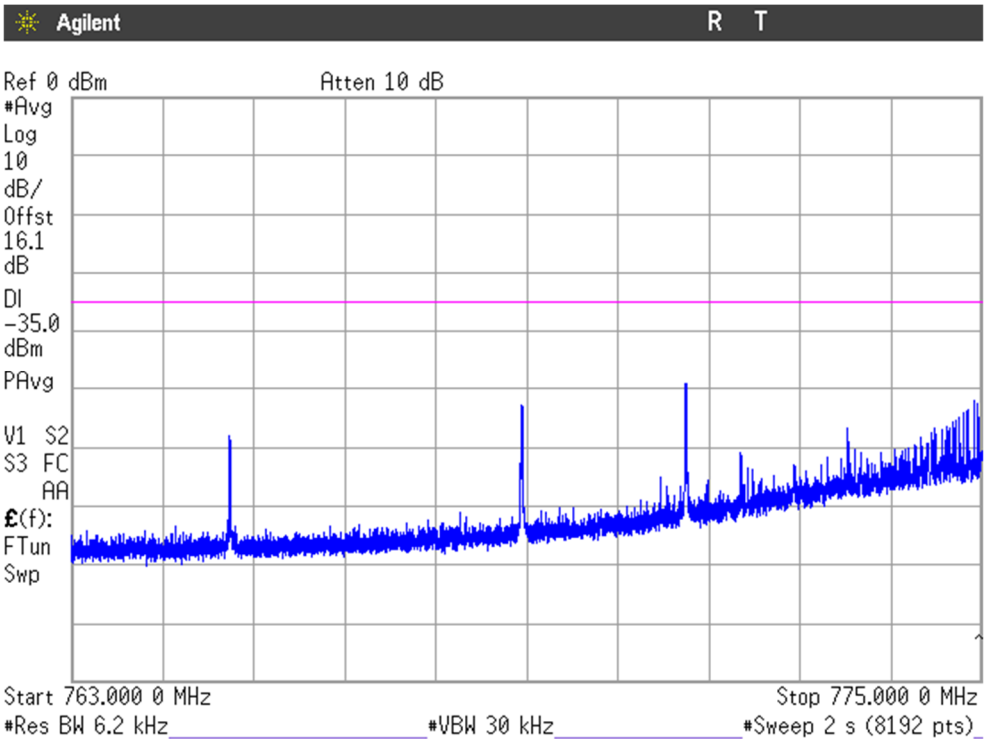
1. CHANNEL: LOWEST

Frequency Range 9 kHz – 8 GHz

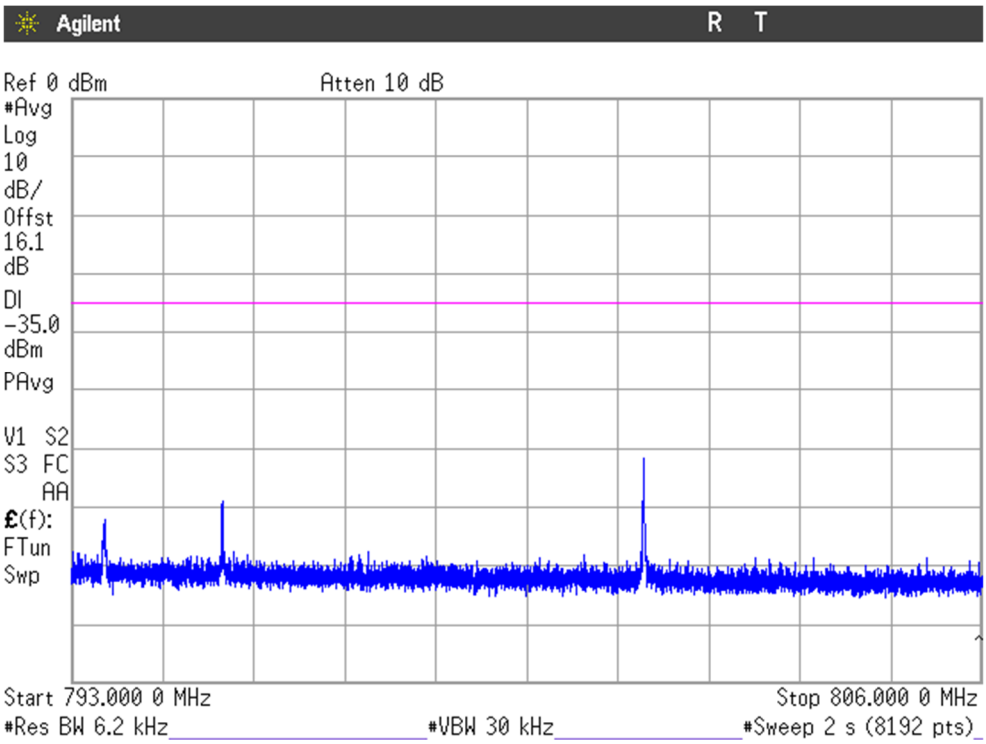



Note: The peak above the limit is the carrier frequency.

Frequency Range 763 MHz - 775 MHz

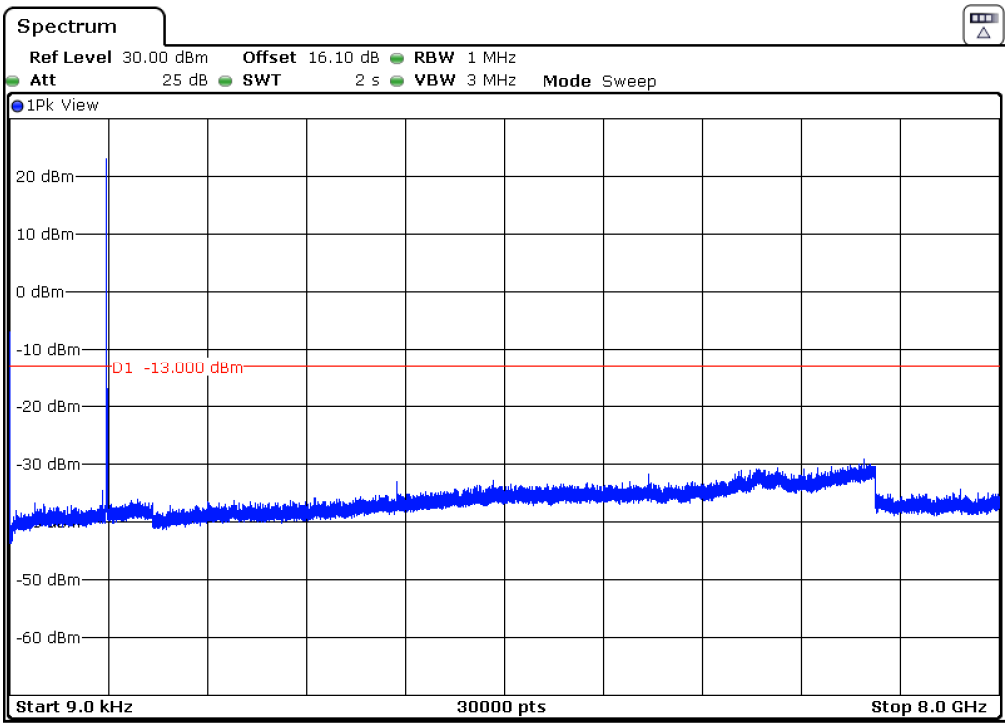


Frequency Range 793 MHz - 806 MHz



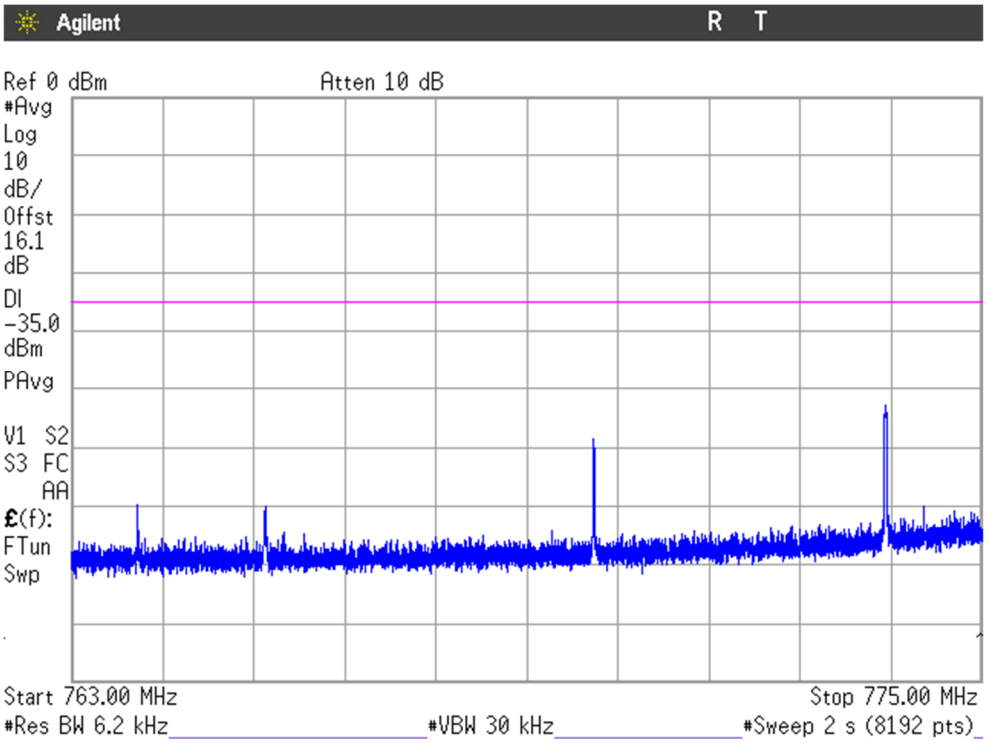

2. CHANNEL: MIDDLE

Frequency Range 9 kHz – 8 GHz

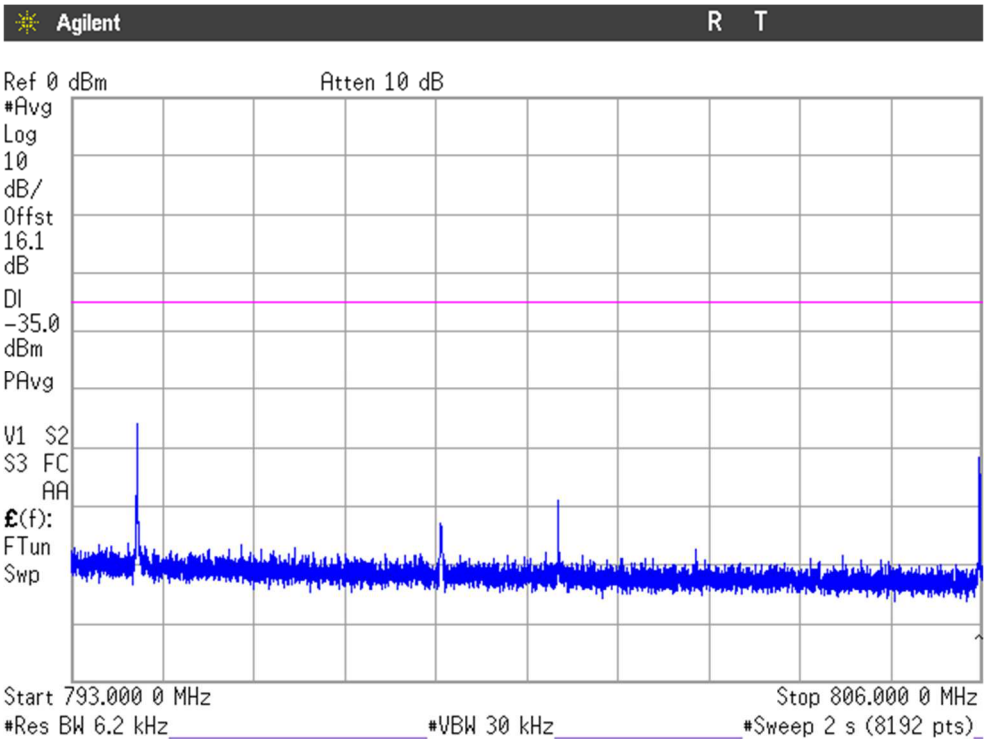



Note: The peak above the limit is the carrier frequency.

Frequency Range 763 MHz - 775 MHz

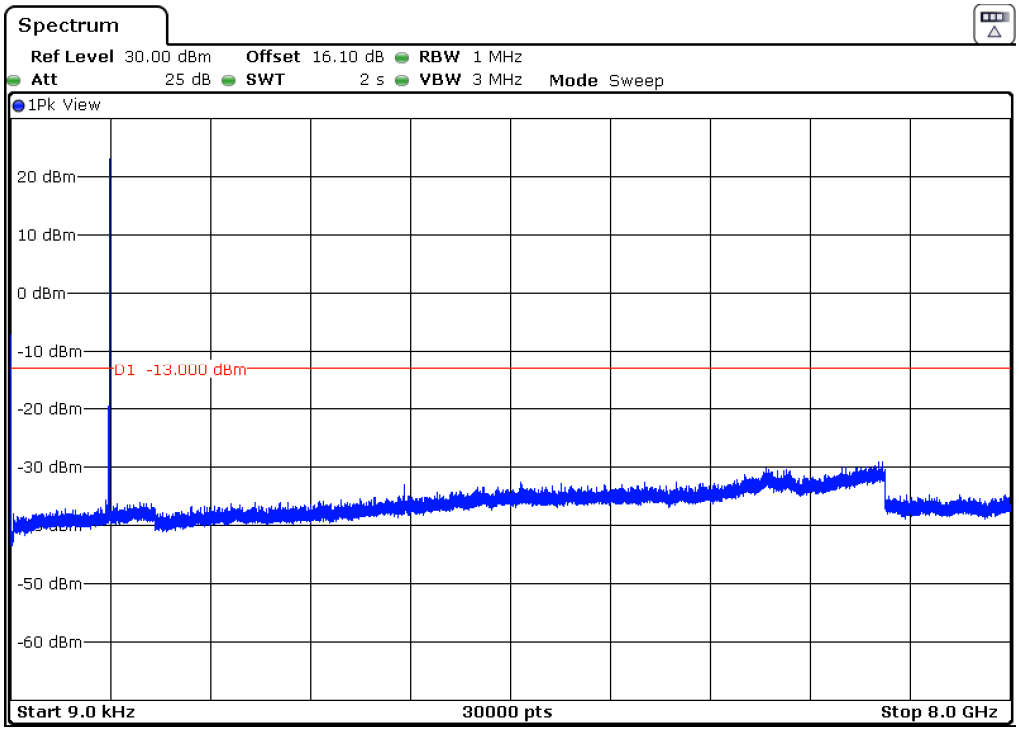



Frequency Range 793 MHz - 806 MHz



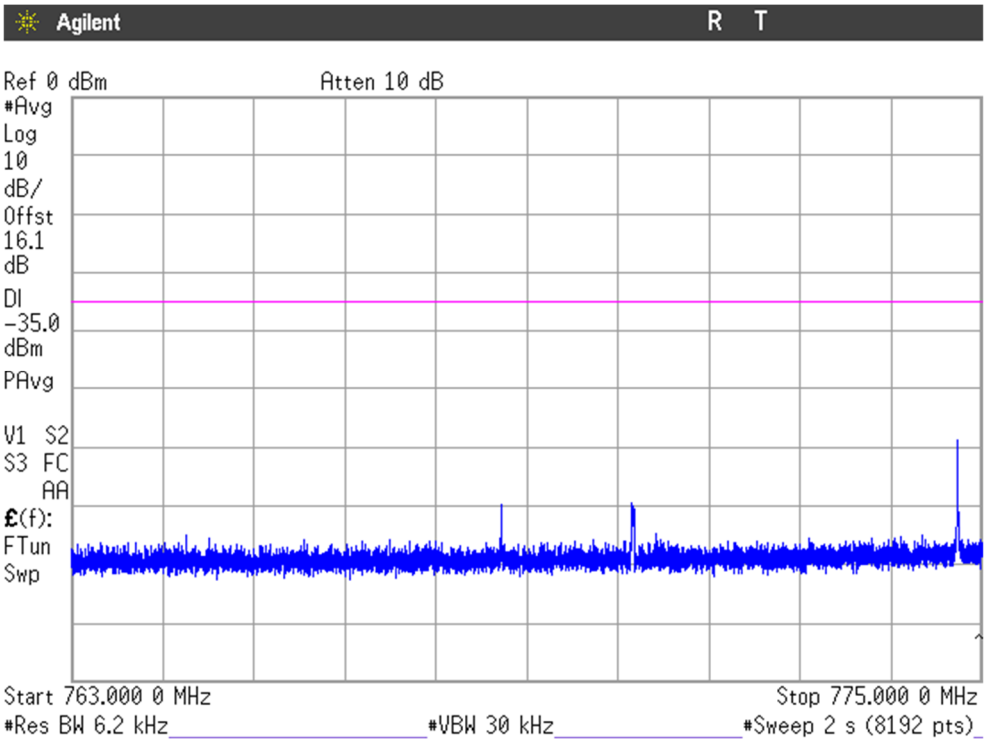
3. CHANNEL: HIGHEST

Frequency Range 9 kHz – 8 GHz

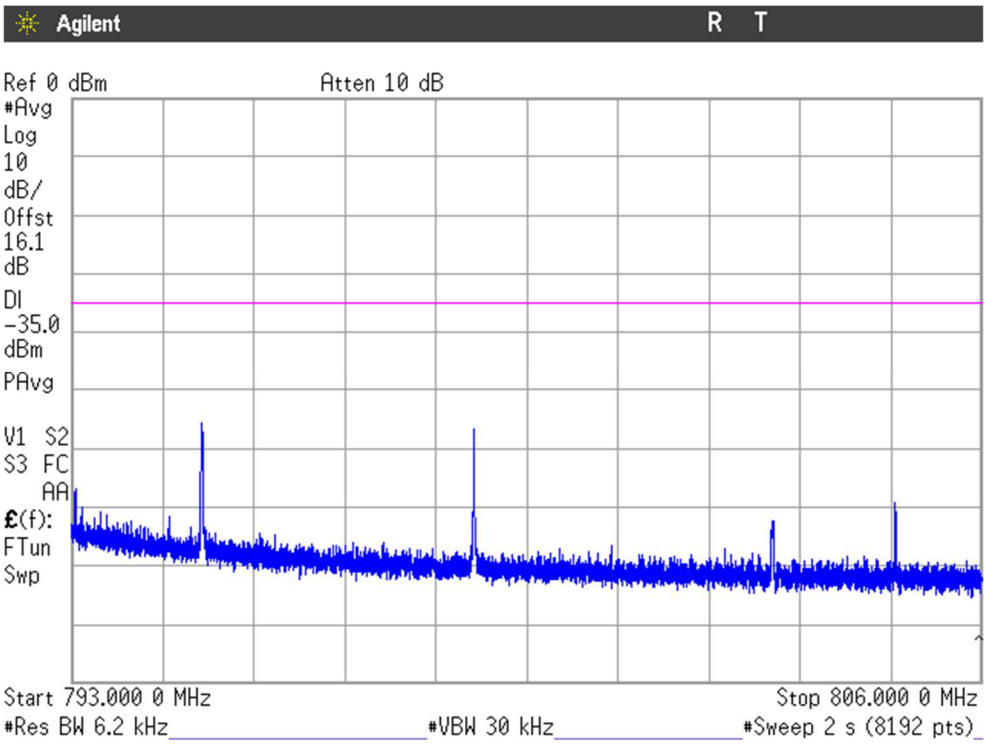



Note: The peak above the limit is the carrier frequency.

Frequency Range 763 MHz - 775 MHz

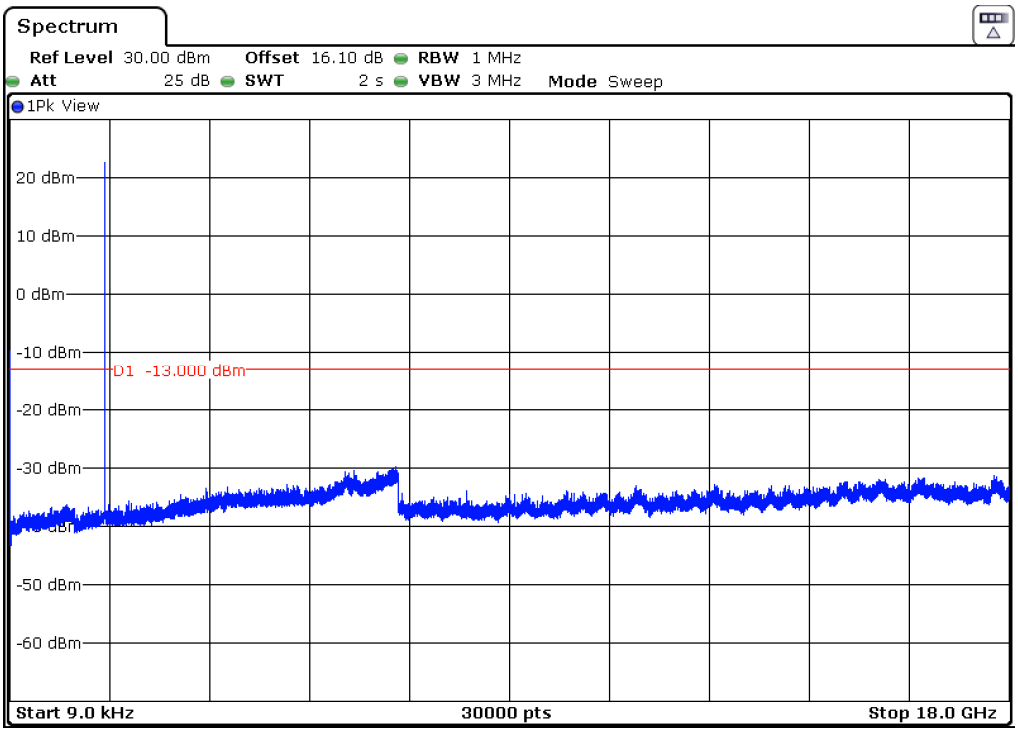


Frequency Range 793 MHz - 806 MHz



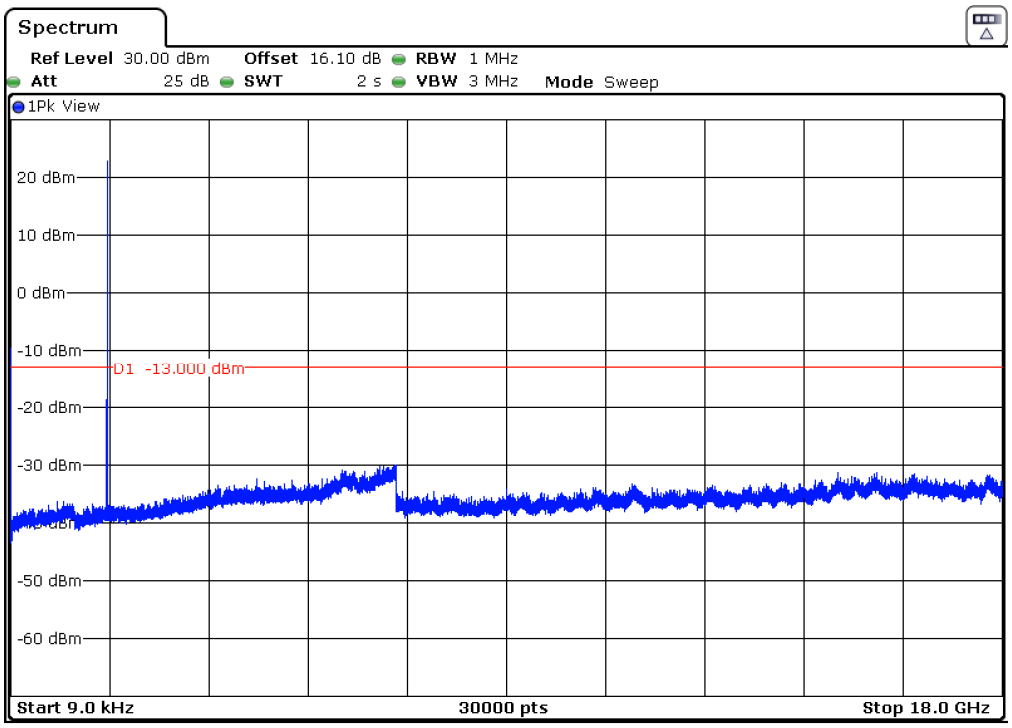

NBIoT Band 66

1. CHANNEL: LOWEST



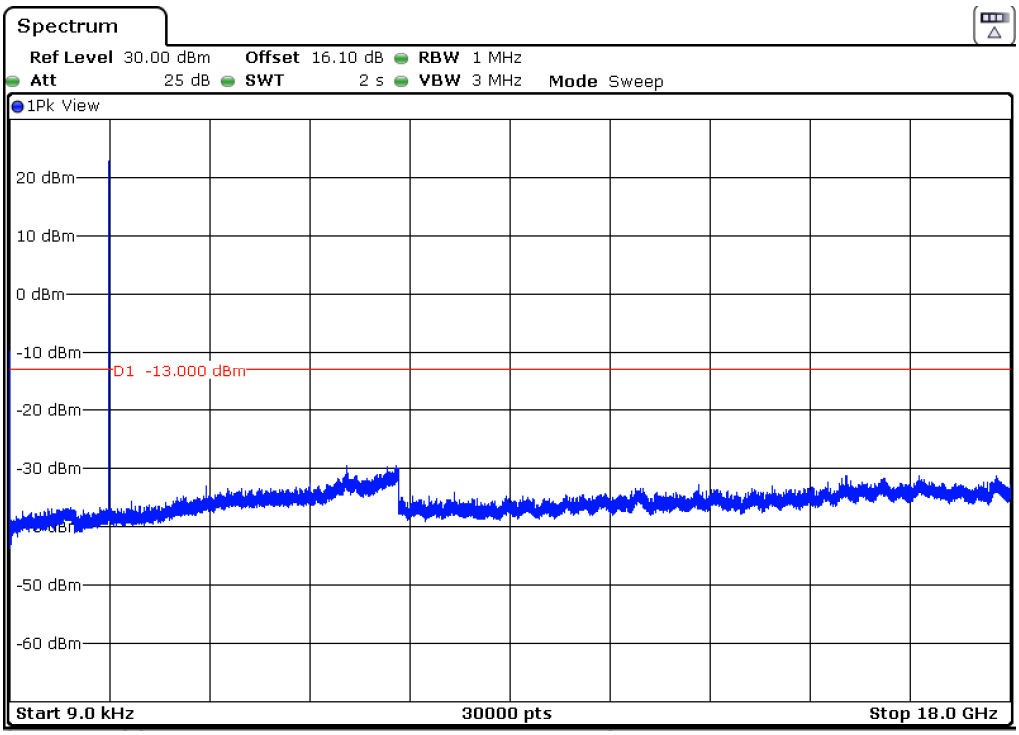

Note: The peak above the limit is the carrier frequency.

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

FCC §27.53 (c) & (g) & (h). RSS-130 Clause 4.6. . RSS-139 Clause 6.6.

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

At Po transmitting power. the specified minimum attenuation becomes 43+10log (Po). and the level in dBm relative Po becomes:
Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = -13 dBm

## METHOD

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

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

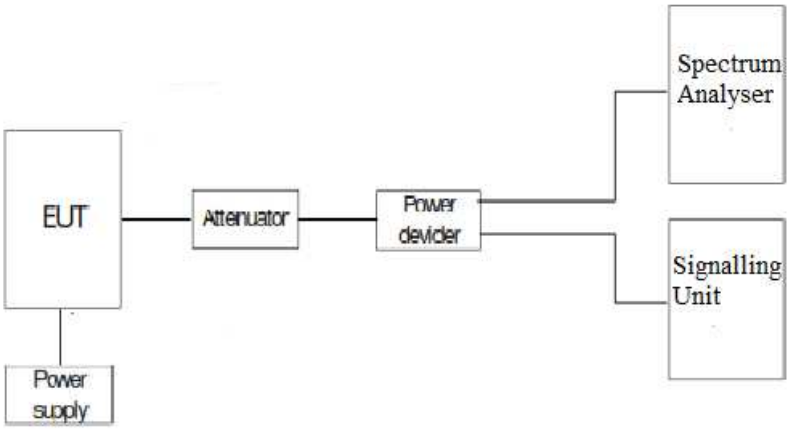
The configuration of modulation which is the worst case for conducted power was used.

For NBIoT Band12. as indicated in FCC part 27.53 (g) /RSS-130 Clause 4.6., in the 100 kHz bands immediately outside and adjacent to the licensee's frequency block or band. a resolution bandwidth of 30 kHz may be employed.

For NBIoT Band 13. as indicated in FCC part 27.53 (c) (5) /RSS-130 Clause 4.6., in the 100 kHz bands immediately outside and adjacent to the licensee's frequency block or band. a resolution bandwidth of 30 kHz may be employed.

For NBIoT Band 66. as indicated in FCC part 27.53 (h) (3) /RSS-139 Clause 6.6.. in the 1 MHz bands immediately outside and adjacent to the licensee's frequency block. a resolution bandwidth of at least one percent of the emission bandwidth/occupied bandwidth of the fundamental emission of the transmitter may be employed.

## TEST SETUP



RESULTS (see plots in next pages)

NBIoT BAND 12.

Preliminary measurements determined a tone with nominal bandwidth of 15 kHz as the worst case. The results in the next tables shows the results for this configuration.

| (Channels in Band 12): | Tone= 15 kHz.<br>Offset=0.<br>π/2 - BPSK |
|---|---|
| Maximum measured level at lowest Block Edge at antenna port (dBm) | -48.04 |

| (Channels in Band 12): | Tone= 15 kHz.<br>Offset=11.<br>π/2 - BPSK |
|---|---|
| Maximum measured level at highest Block Edge at antenna port (dBm) | -19.66 |

NBIoT. BAND 13.

Preliminary measurements determined a tone with nominal bandwidth of 15 kHz as the worst case. The results in the next tables shows the results for this configuration.

| (Channels in Band 13): | Tone= 15 kHz.<br>Offset=0.<br>π/2 - BPSK |
|---|---|
| Maximum measured level at lowest Block Edge at antenna port (dBm) | -19.53 |

| (Channels in Band 13): | Tone= 15 kHz.<br>Offset=11.<br>π/2 - BPSK |
|---|---|
| Maximum measured level at highest Block Edge at antenna port (dBm) | -19.74 |

NBIoT. BAND 66.

Preliminary measurements determined a tone with nominal bandwidth of 15 kHz as the worst case. The results in the next tables shows the results for this configuration.

| (Channels in Band 66): | Tone= 15 kHz.<br>Offset=0.<br>π/2 - BPSK |
|---|---|
| Maximum measured level at lowest Block Edge at antenna port (dBm) | -23.72 |

| (Channels in Band 66): | Tone= 15 kHz.<br>Offset=11.<br>π/2 - BPSK |
|---|---|
| Maximum measured level at highest Block Edge at antenna port (dBm) | -22.38 |

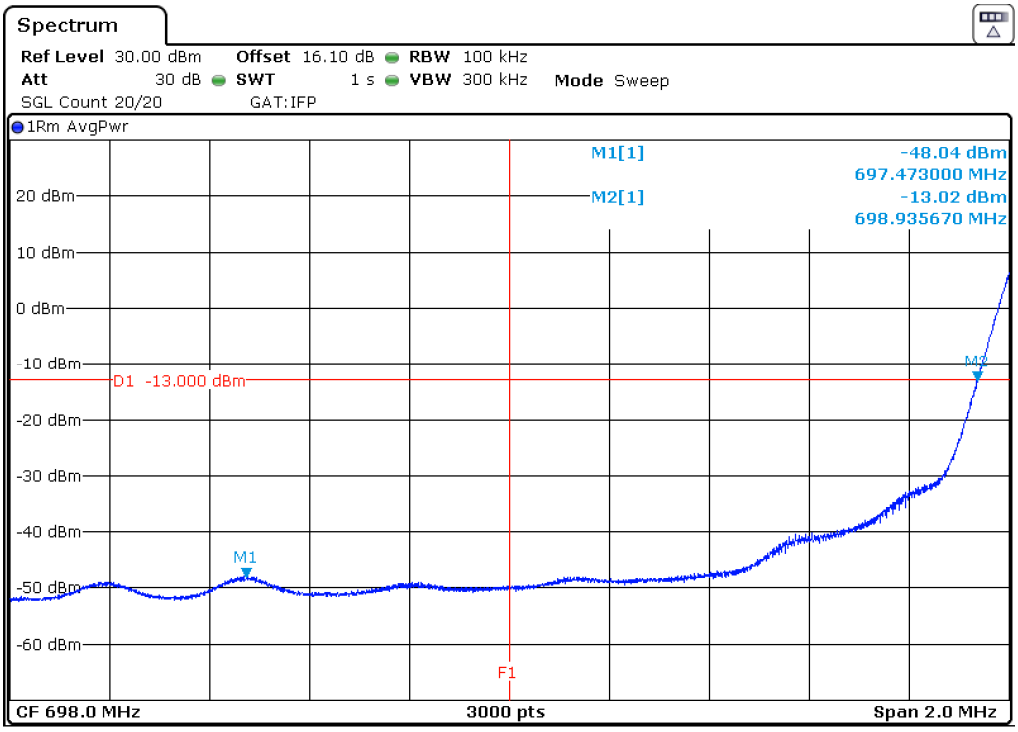
Measurement uncertainty = <±1.20 dB.

Verdict: PASS

NBIoT. BAND 12.

1 tone π/2 – BPSK. BW=15 kHz Offset = 0

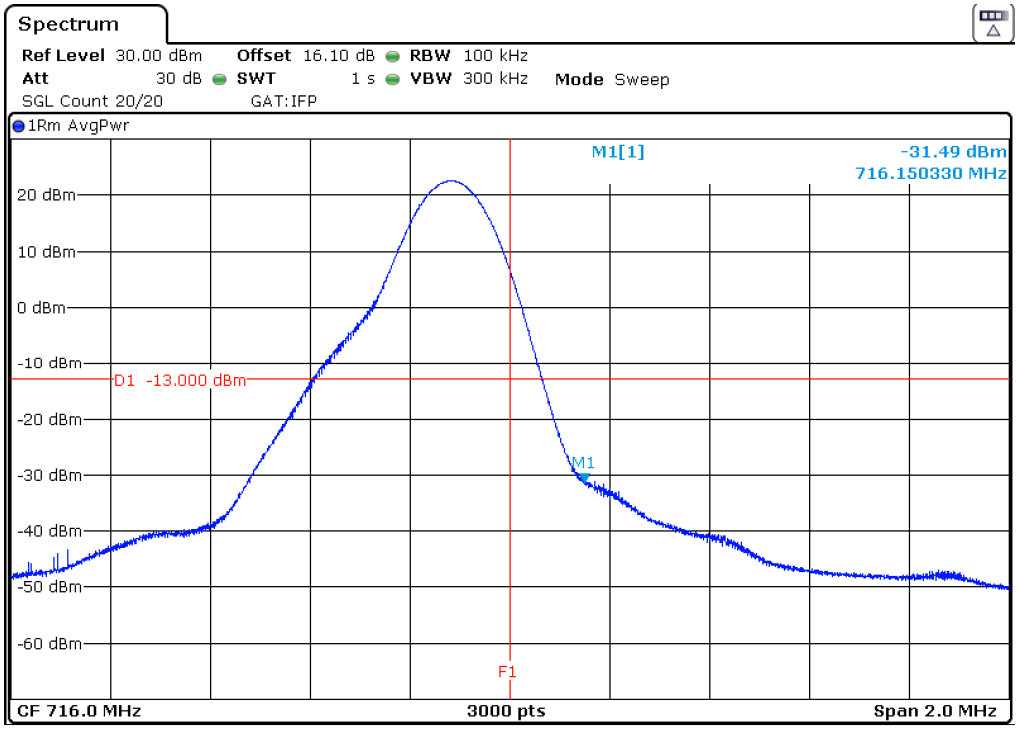
CHANNEL LOWEST



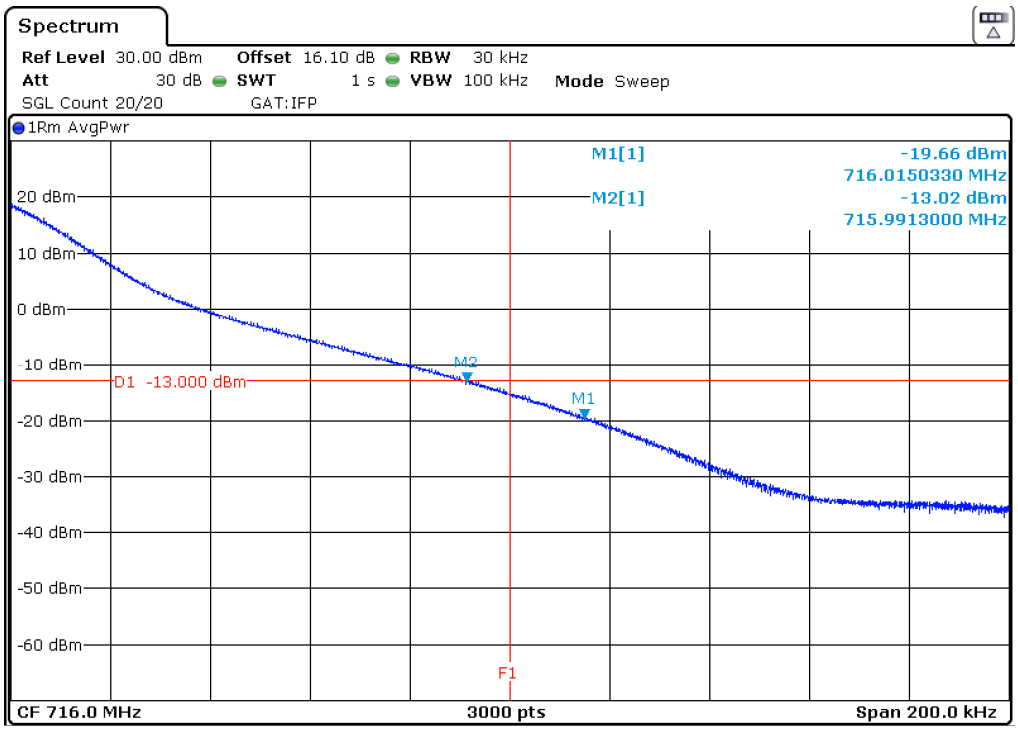

NOTE: The equipment transmits at the maximum output power

1 tone π/2 – BPSK. BW=15 kHz Offset = 11

CHANNEL HIGHEST




NOTE: The equipment transmits at the maximum output power

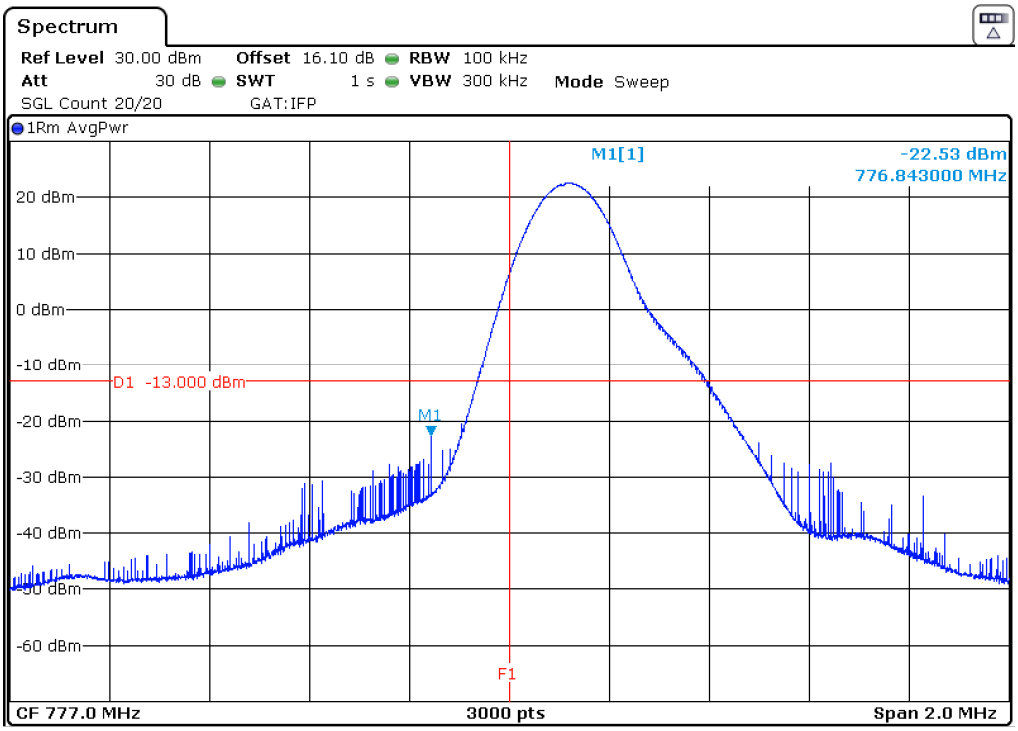



NOTE: Zoom (100KHz) with RBW=30KHz.

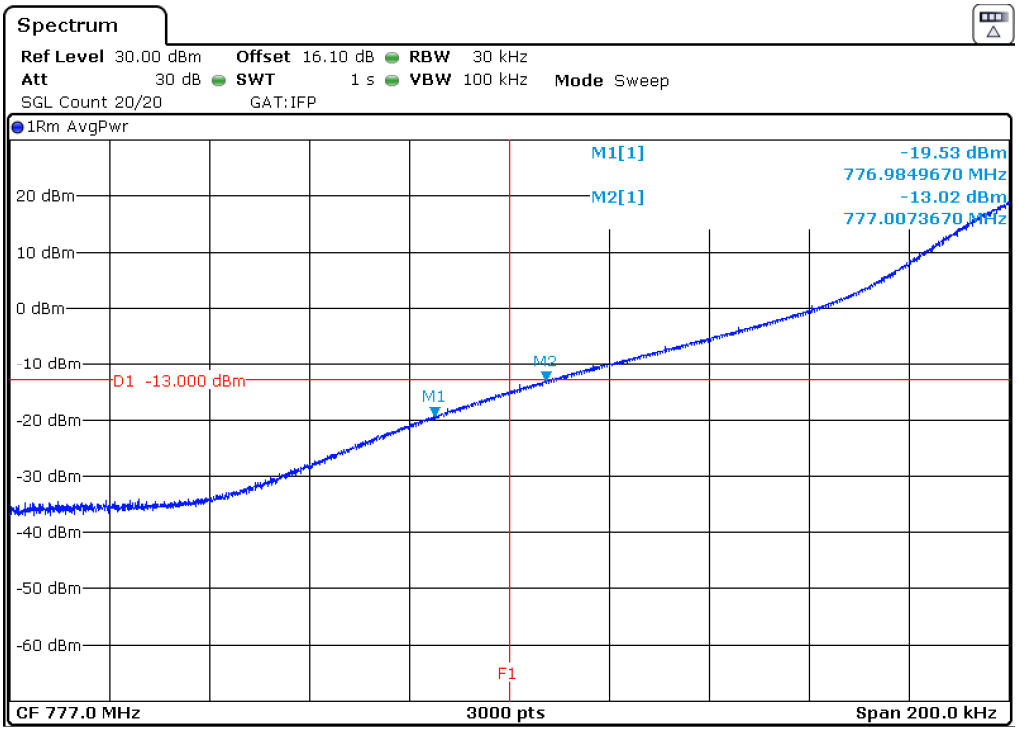
NBIoT. BAND 13.

1 tone π/2 – BPSK. BW=15 kHz Offset = 0

CHANNEL LOWEST



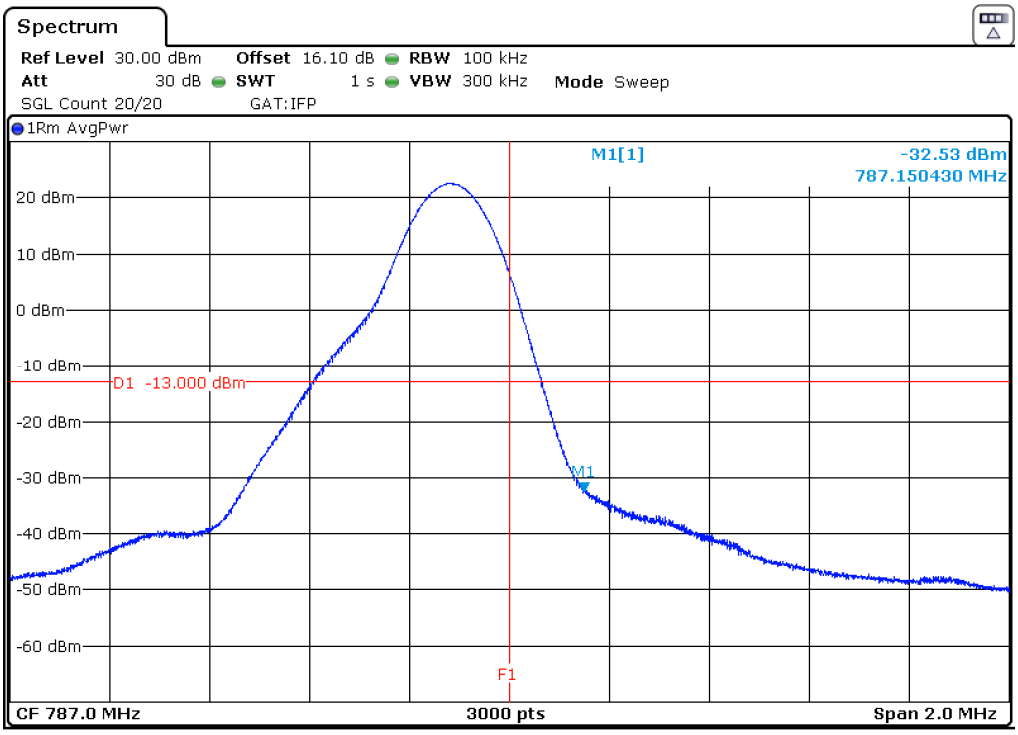

NOTE: The equipment transmits at the maximum output power



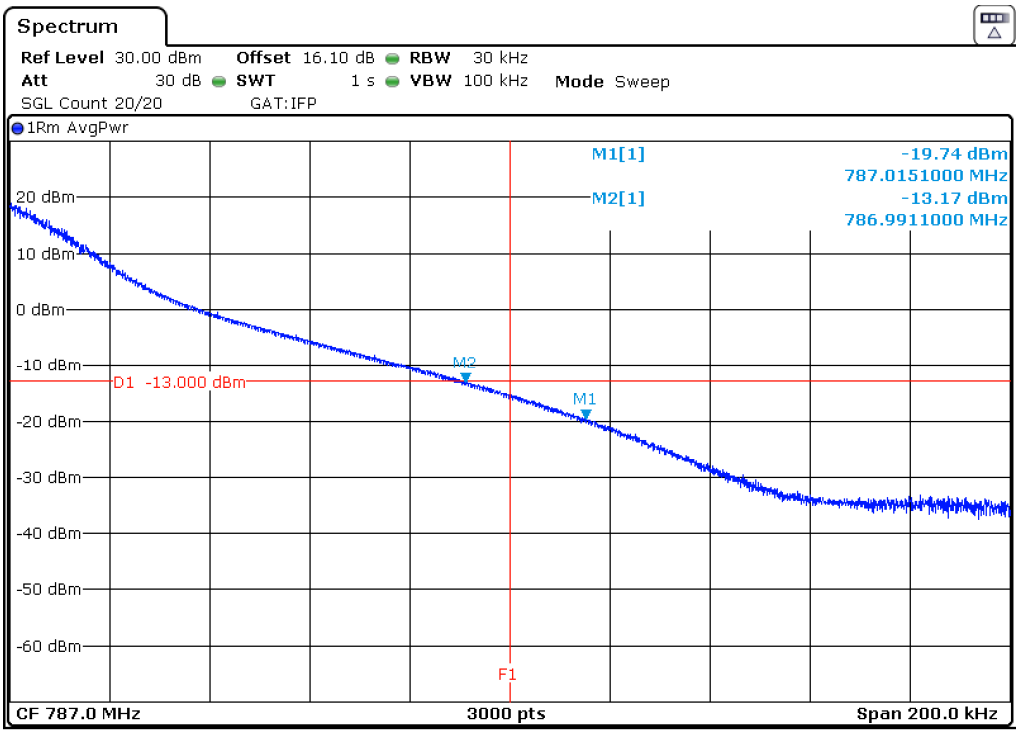

NOTE: Zoom (100KHz) with RBW=30KHz.

1 tone π/2 – BPSK. BW=15 kHz Offset = 11

CHANNEL HIGHEST




NOTE: The equipment transmits at the maximum output power

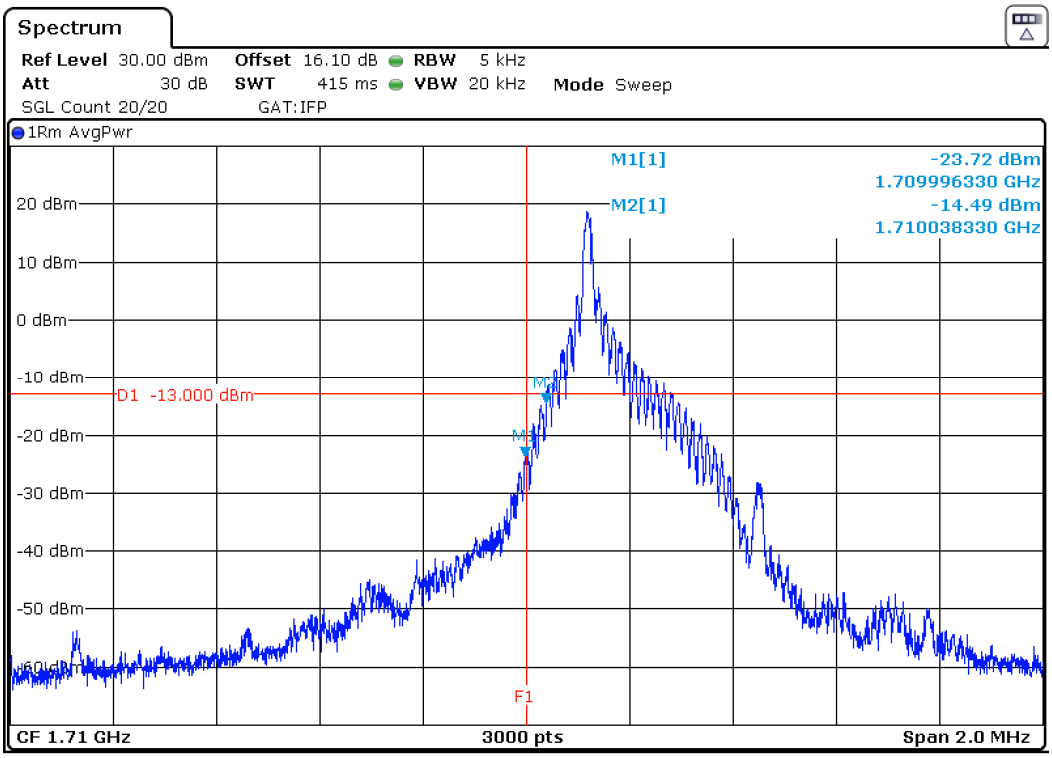



NOTE: Zoom (100KHz) with RBW=30KHz.

NBIoT. BAND 66.

1 tone π/2 – BPSK. BW=15 kHz Offset = 0

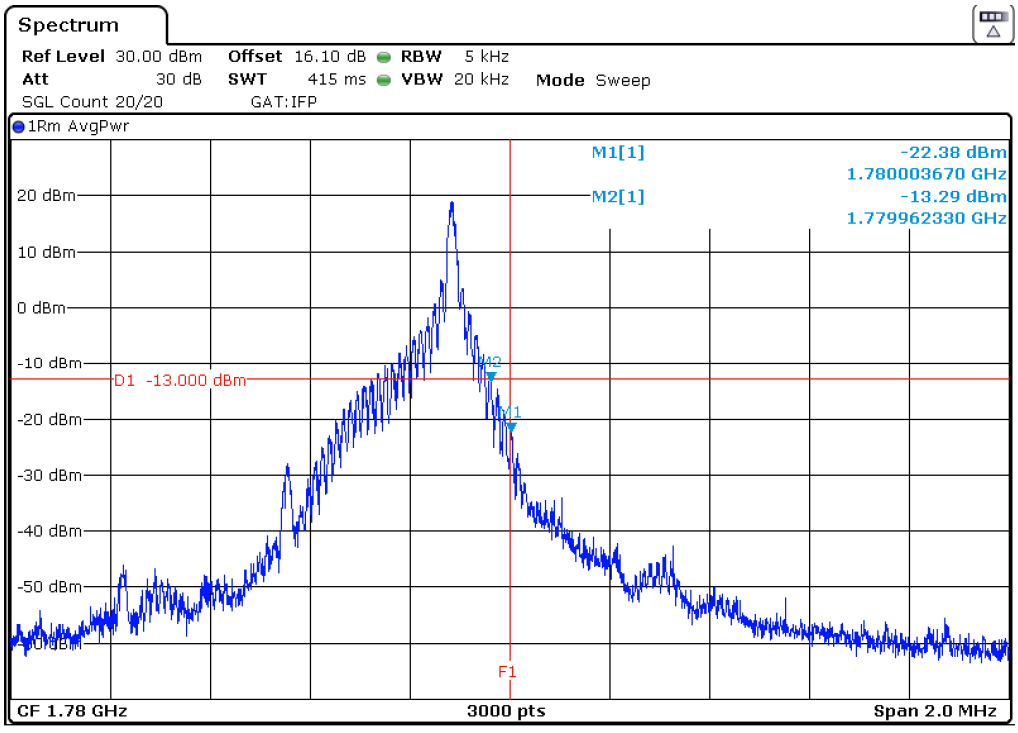
CHANNEL LOWEST




NOTE: The equipment transmits at the maximum output power

1 tone π/2 – BPSK. BW=15 kHz Offset = 11

CHANNEL HIGHEST




NOTE: The equipment transmits at the maximum output power

# Radiated emissions

## SPECIFICATION

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. However. in the 100 kilohertz bands immediately outside and adjacent to a licensee's frequency block. a resolution bandwidth of at least 30 kHz may be employed

FCC §27.53 (c) & (f).
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.

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.

For operations in the 746-758 MHz. 775-788 MHz. and 805-806 MHz bands. emissions in the band 1559-1610 MHz shall be limited to –70 dBW (-40 dBm)/MHz equivalent isotropically radiated power (EIRP) for wideband signals. and –80 dBW (-50 dBm) EIRP for discrete emissions of less than 700 Hz bandwidth.

RSS-130 Clause 4.6.
The power of any unwanted emissions in any 100 kHz bandwidth on any frequency outside the frequency range(s) within which the equipment is designed to operate shall be attenuated below the transmitter power. P (dBW). by at least 43 + 10 log10 p (watts). dB.

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 65 + 10 log10 p(watts). dB. for mobile and portable equipment.

The e.i.r.p. in the band 1559-1610 MHz shall not exceed -70 dBW (-40 dBm) /MHz for wideband signal and -80 dBW (-50 dBm) for discrete emission with bandwidth less than 700 Hz.

FCC §27.53 (h). RSS-139 Clause 6.6.
According to specification. the power of emissions shall be attenuated below the transmitter power (P) by a factor of at least 43 + 10 log (P) dB. P in watts.

At Po transmitting power. the specified minimum attenuation becomes 43+10 log (Po). and the level in dBm relative Po becomes:
Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = -13 dBm.

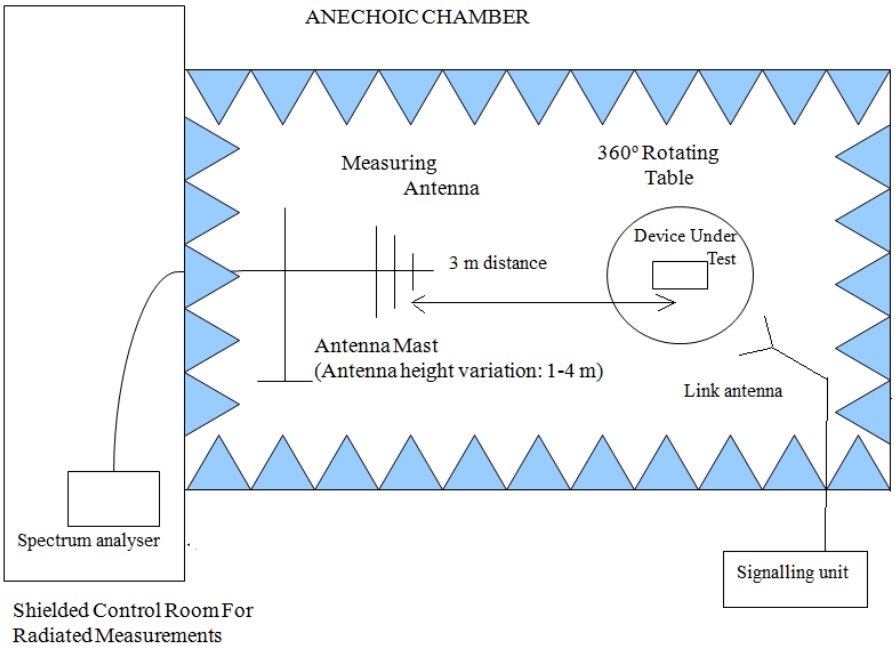
At Po transmitting power. the specified minimum attenuation becomes 65+10 log (Po). and the level in dBm relative Po becomes:
Po (dBm) – [65 + 10 log (Po in mwatts) - 30] = -35 dBm.

## METHOD

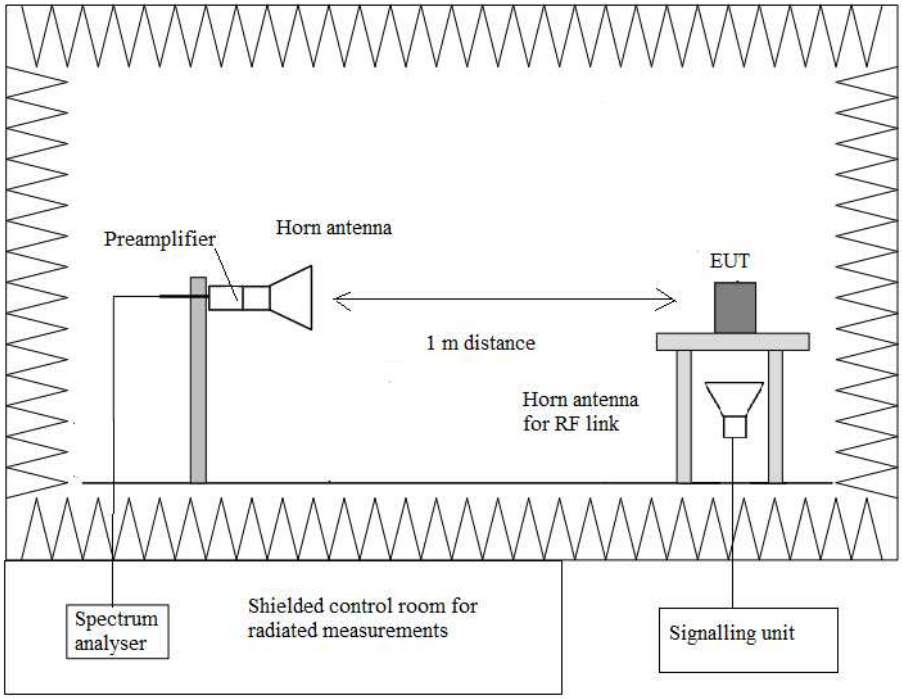
The measurement was performed with the EUT inside an anechoic chamber. The spectrum was scanned from 30 MHz to at least the 10th harmonic of the highest frequency generated within the equipment.
The EUT was placed on a non-conductive stand at a 3 meter distance from the measuring antenna for measurements below 1 GHz and at 1 m distance for measurements above 1 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.
Each detected emission at less than 20 dB respect to the limit is substituted by the Substitution method in accordance with the ANSI/TIA-603-E: 2016.

## TEST SETUP

Radiated measurements below 1 GHz.




Radiated measurements above 1 GHz.



RESULTS

NBIoT. BAND 12.

Preliminary measurements determined that 3 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

1. CHANNEL: LOWEST

**Frequency range 30 MHz-1000 MHz**.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 1 GHz-8 GHz**.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

2. CHANNEL: MIDDLE

**Frequency range 30 MHz-1000 MHz**.

No radiated spurious signals were detected.

**Frequency range 1 GHz-8 GHz**.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

3. CHANNEL: HIGHEST

**Frequency range 30 MHz-1000 MHz**.

No radiated spurious signals were detected.

**Frequency range 1 GHz-8 GHz**.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

NBIoT. BAND 13.

Preliminary measurements determined that 3 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

1. CHANNEL: LOWEST

**Frequency range 30 MHz-1000 MHz**.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 1 GHz-8 GHz**.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 1559 MHz-1610 MHz**.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

2. CHANNEL: MIDDLE

**Frequency range 30 MHz-1000 MHz**.

No radiated spurious signals were detected.

**Frequency range 1 GHz-8 GHz**.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 1559 MHz-1610 MHz**.

Substitution method data

| Frequency (MHz) | Instrument reading (dBm) | Polarization | RBW | (1) Generator output (dBm) | (2) Cable loss (dB) | (3) Substitution antenna gain Gi (respect to isotropic radiator) (dB) | E.I.R.P. (dBm) = (1) – (2) + (3) |
|---|---|---|---|---|---|---|---|
| 1563.82 | -56.59 | Horizontal | 1 kHz | -68.36 | 1.14 | 8.33 | -61.17 |
| 1564.63 | -46.52 | Horizontal | 1 MHz | -58.28 | 1.14 | 8.33 | -51.09 |

No discrete signals were detected. Only wideband signals were detected.

3. CHANNEL: HIGHEST

**Frequency range 30 MHz-1000 MHz**.

No radiated spurious signals were detected.

**Frequency range 1 GHz-8 GHz**.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 1559 MHz-1610 MHz**.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

NBIoT. BAND 66.

Preliminary measurements determined that 3 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

1. CHANNEL: LOWEST
**Frequency range 30 MHz-1000 MHz.**

No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 1 GHz-18 GHz.**

No radiated spurious signals were detected at less than 20 dB respect to the limit.

2. CHANNEL: MIDDLE
**Frequency range 30 MHz-1000 MHz**.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 1 GHz-18 GHz**.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

3. CHANNEL: HIGHEST
**Frequency range 30 MHz-1000 MHz.**

No radiated spurious signals were detected at less than 20 dB respect to the limit.

**Frequency range 1 GHz-18 GHz**.

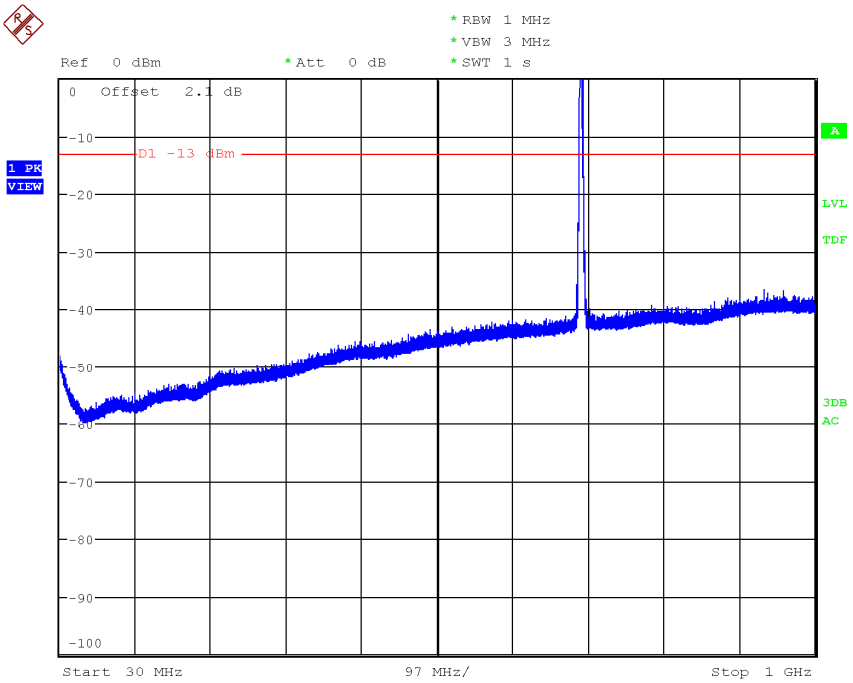
No radiated spurious signals were detected at less than 20 dB respect to the limit.

Verdict: PASS

FREQUENCY RANGE 30 MHz-1000 MHz.

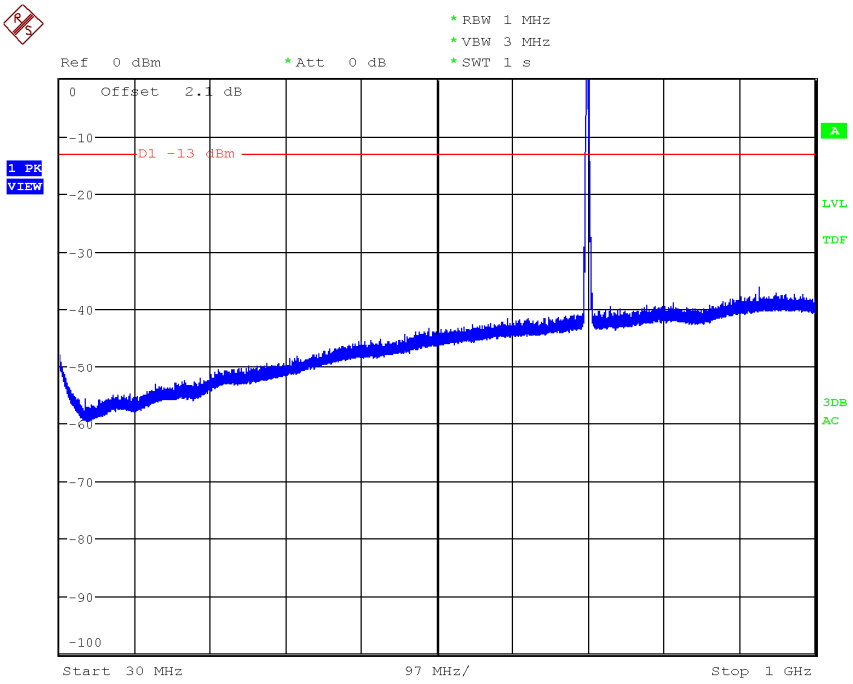
**NBIoT Band 12**

CHANNEL: LOWEST



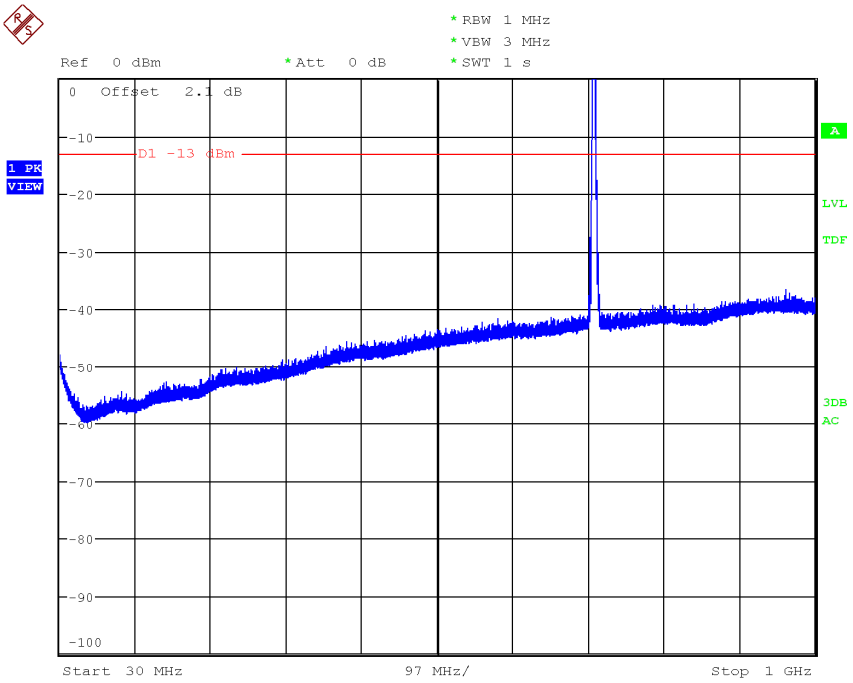

Note: The peak above the limit is the carrier frequency.

CHANNEL: MIDDLE




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

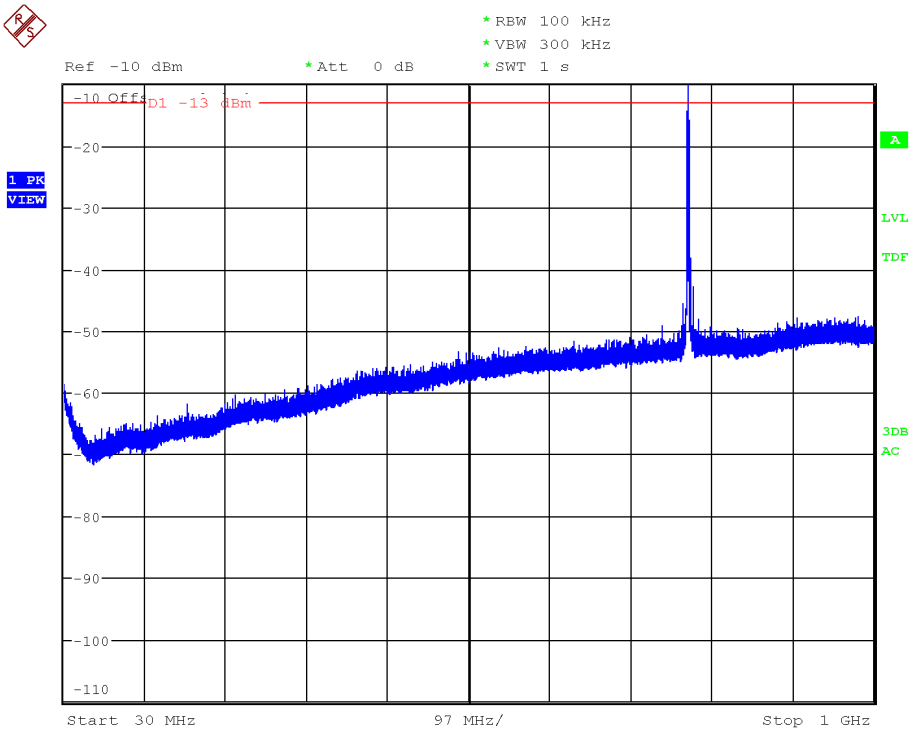
CHANNEL: HIGHEST




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

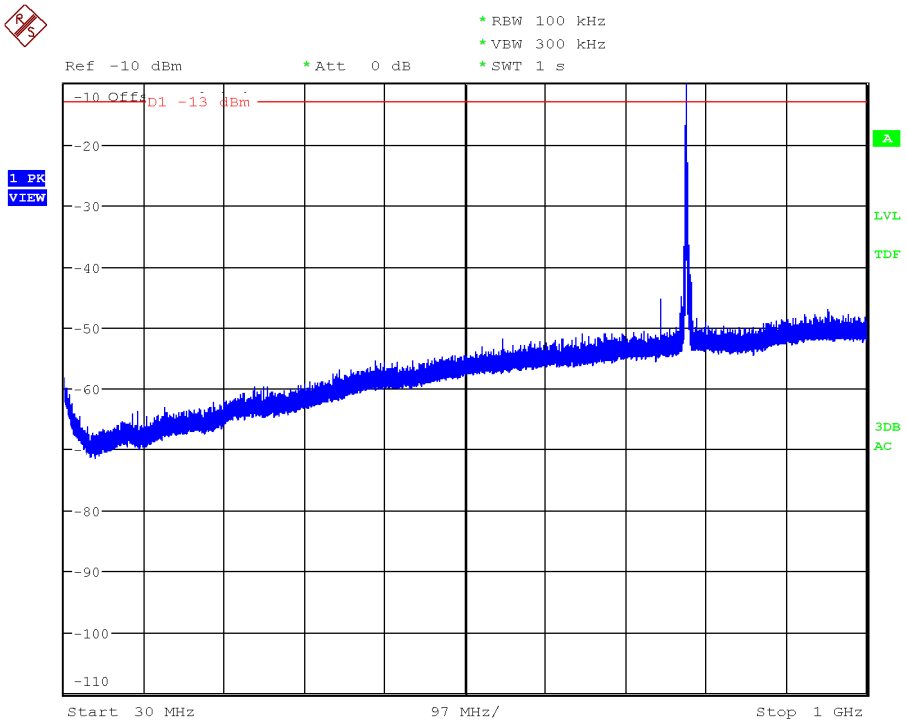
**NBIoT Band 13**

CHANNEL: LOWEST



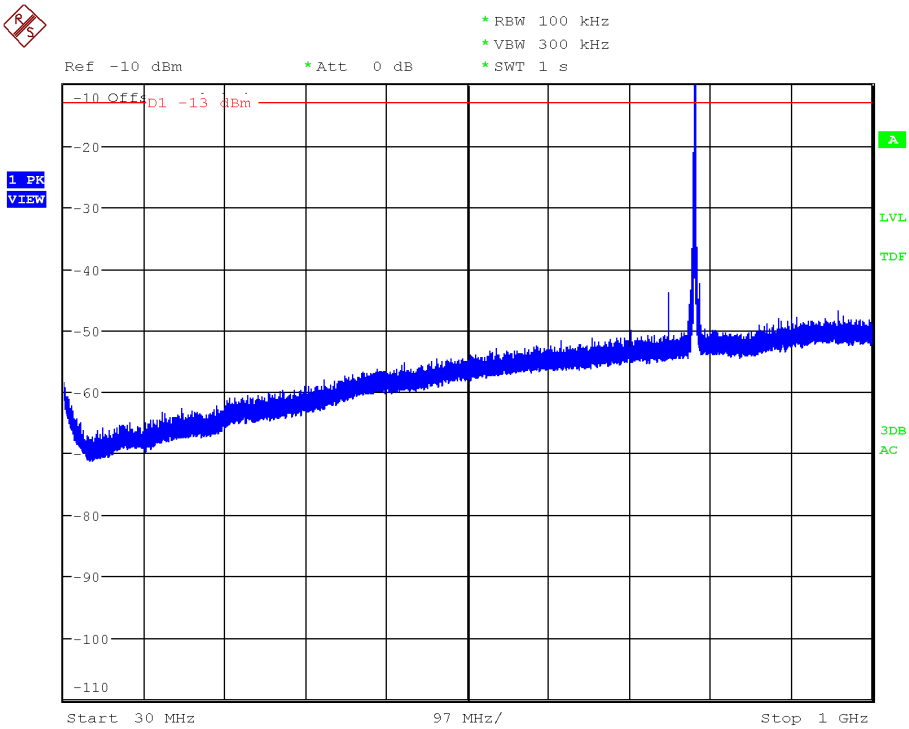

Note: The peak above the limit is the carrier frequency.

CHANNEL: MIDDLE



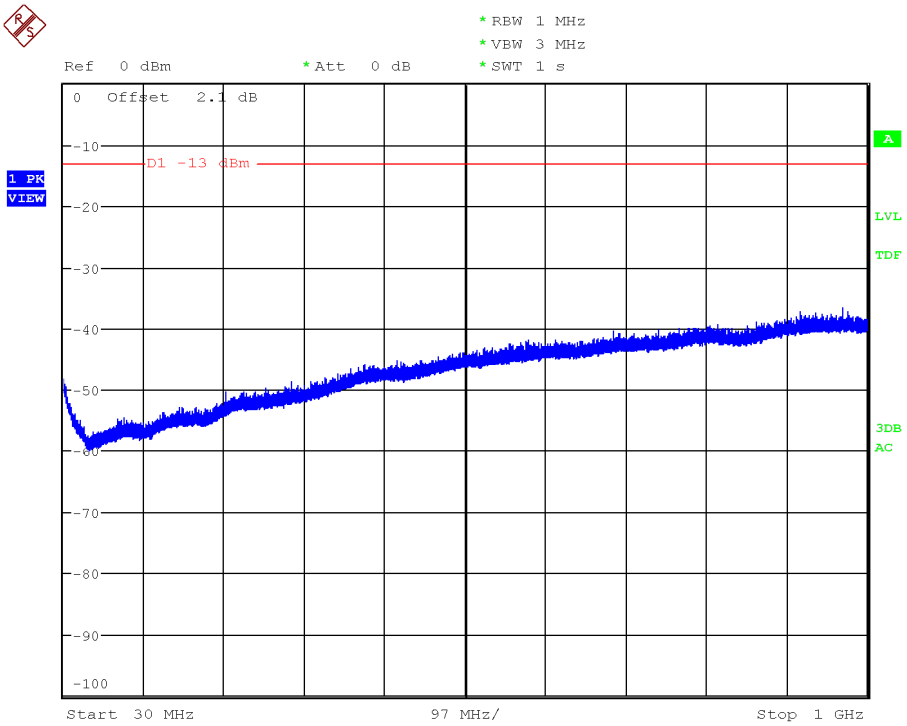

Note: The peak above the limit is the carrier frequency.

CHANNEL: HIGHEST




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

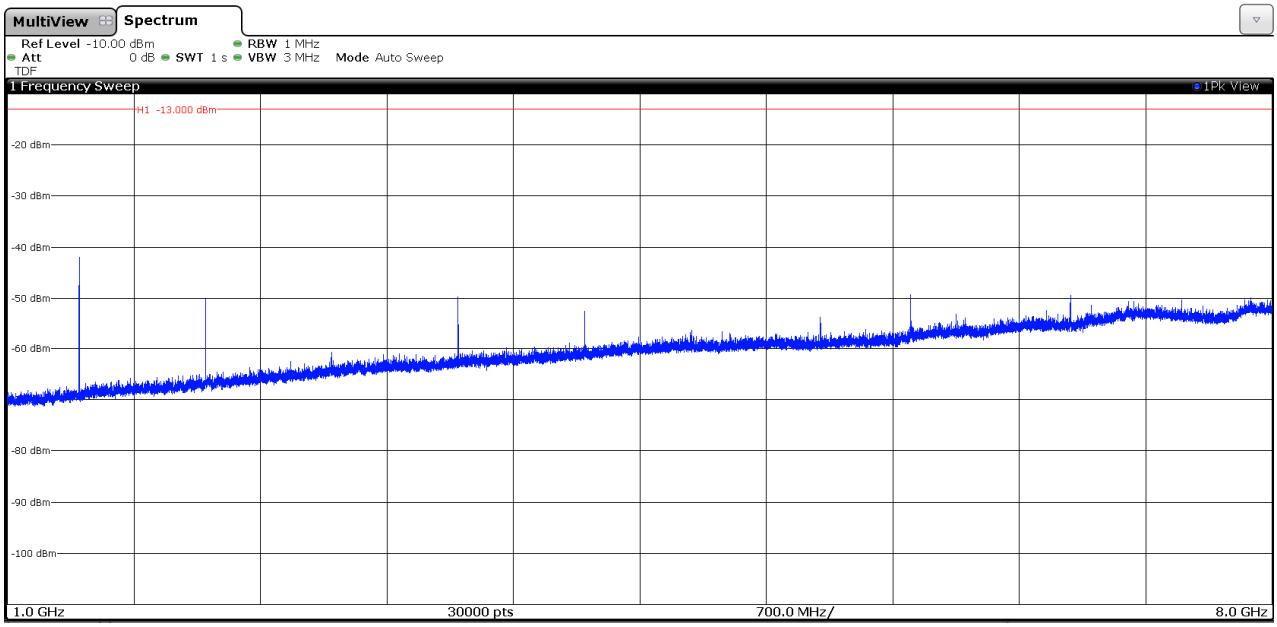
## NBIoT Band 66



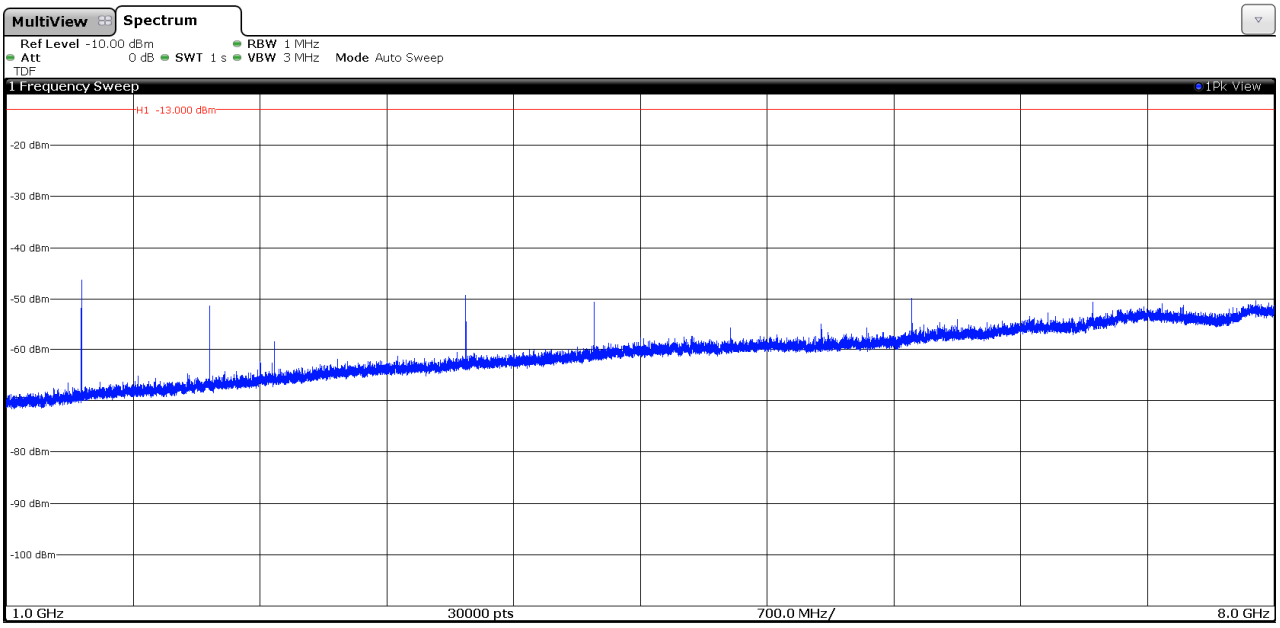

(This plot is valid for all three channels)

## NBIoT Band 12. Frequency range 1 GHz to 8 GHz.

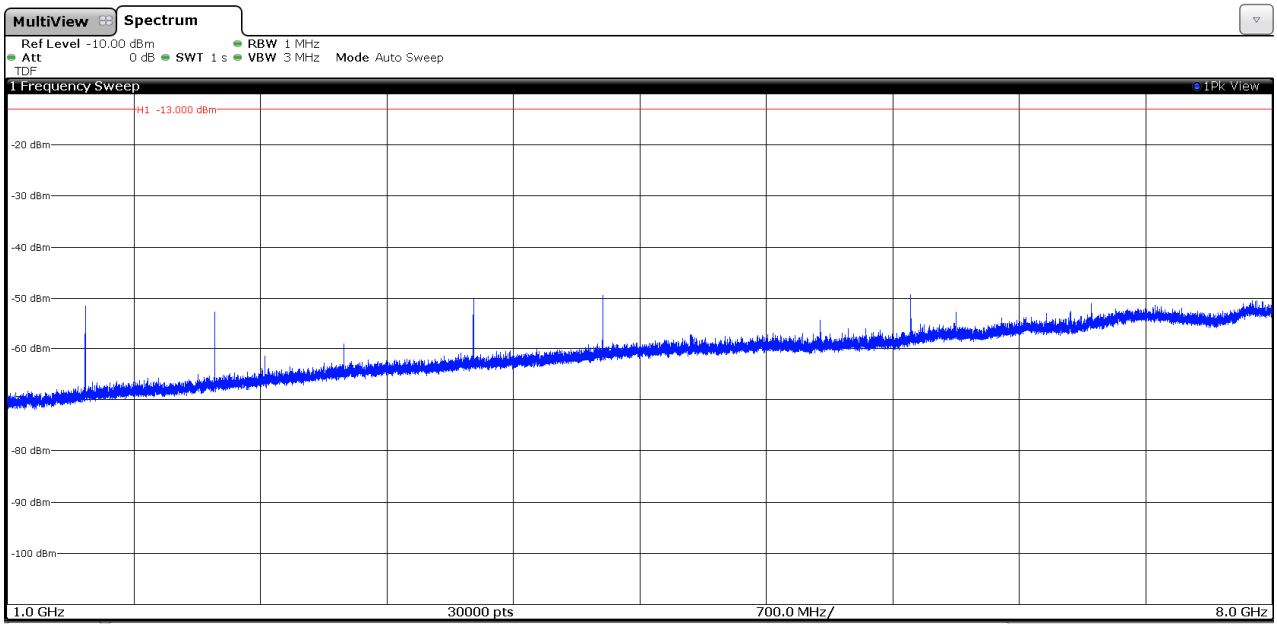
CHANNEL: LOWEST



## CHANNEL: MIDDLE

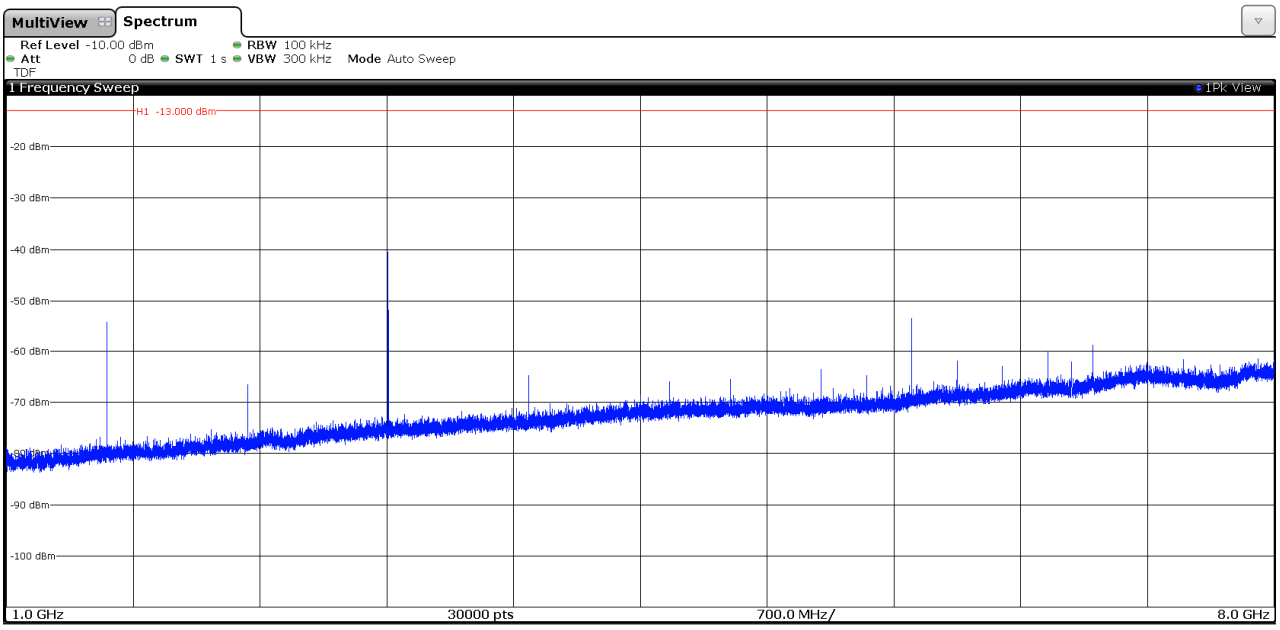



## CHANNEL: HIGHEST

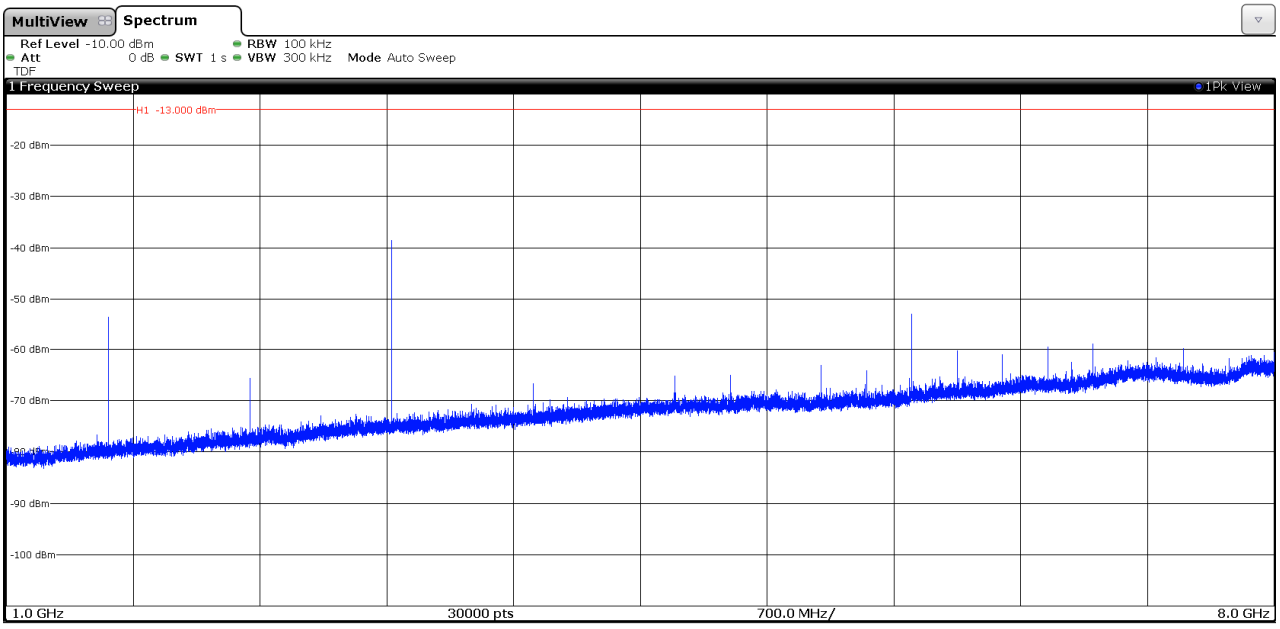


## NBIoT Band 13. Frequency range 1 GHz to 8 GHz.

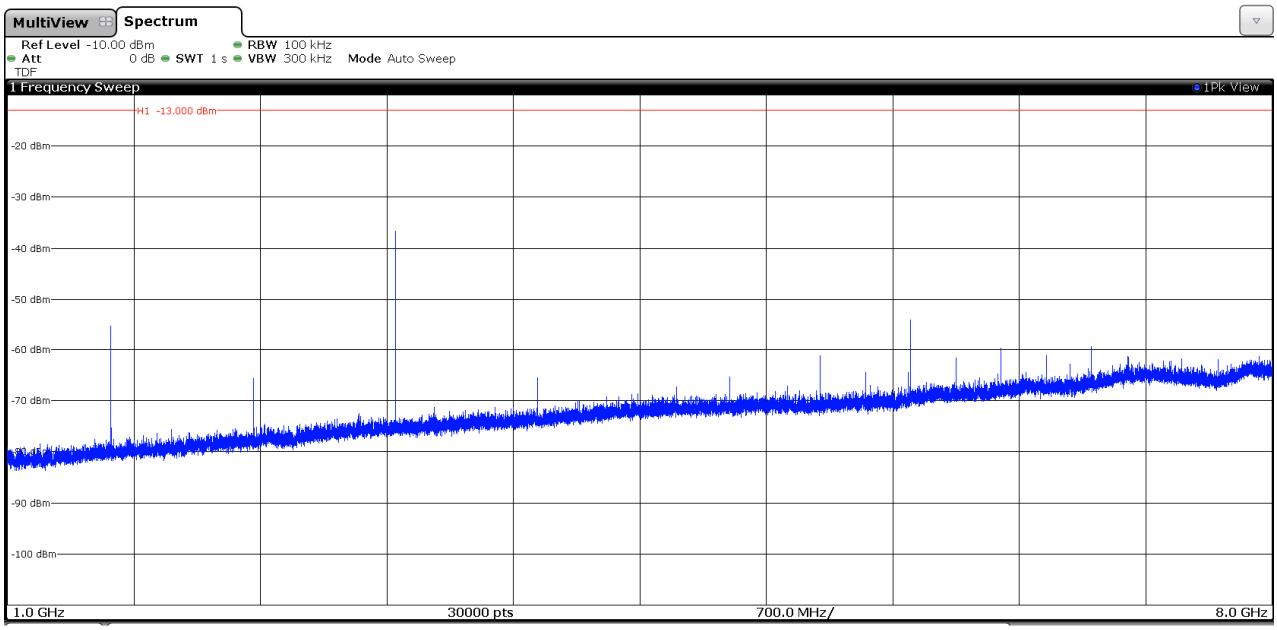
CHANNEL: LOWEST




CHANNEL: MIDDLE

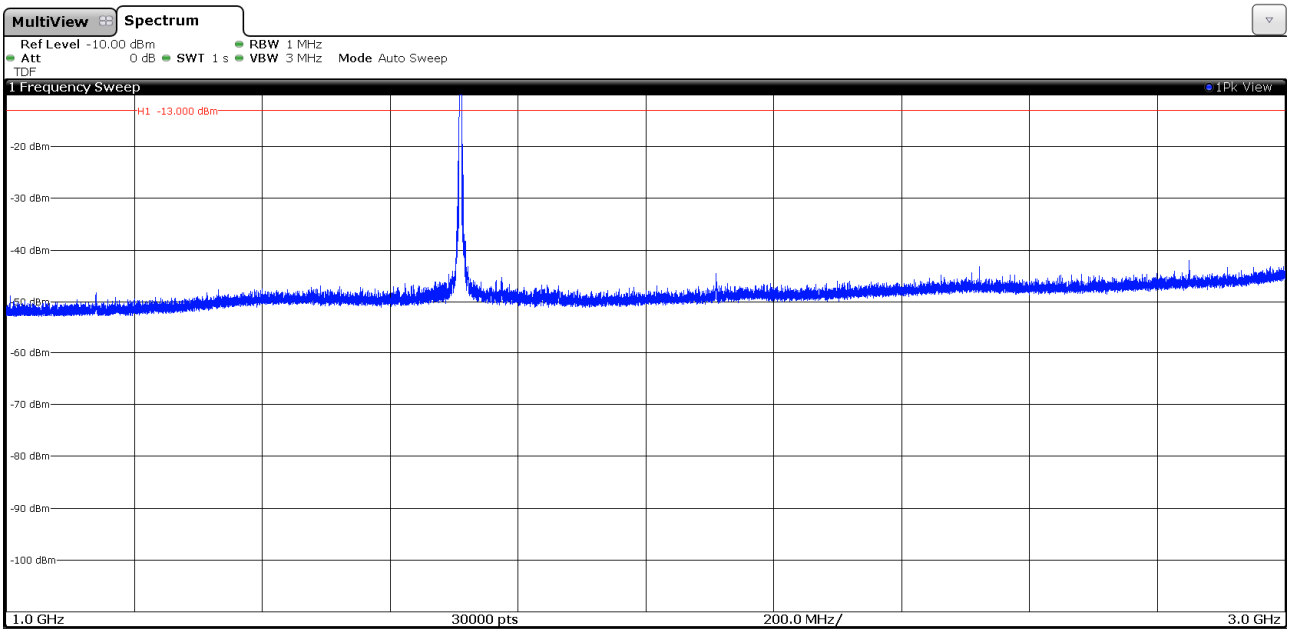


CHANNEL: HIGHEST



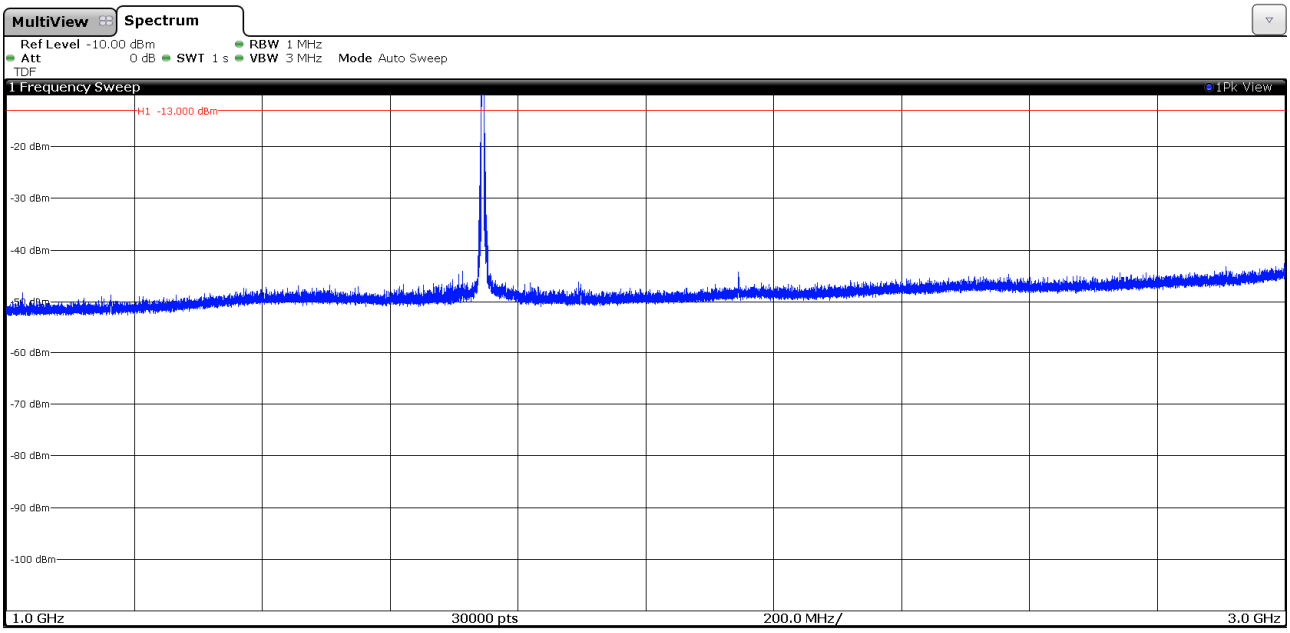

**NBIoT Band 66. Frequency range 1 GHz to 3 GHz**

CHANNEL: LOWEST



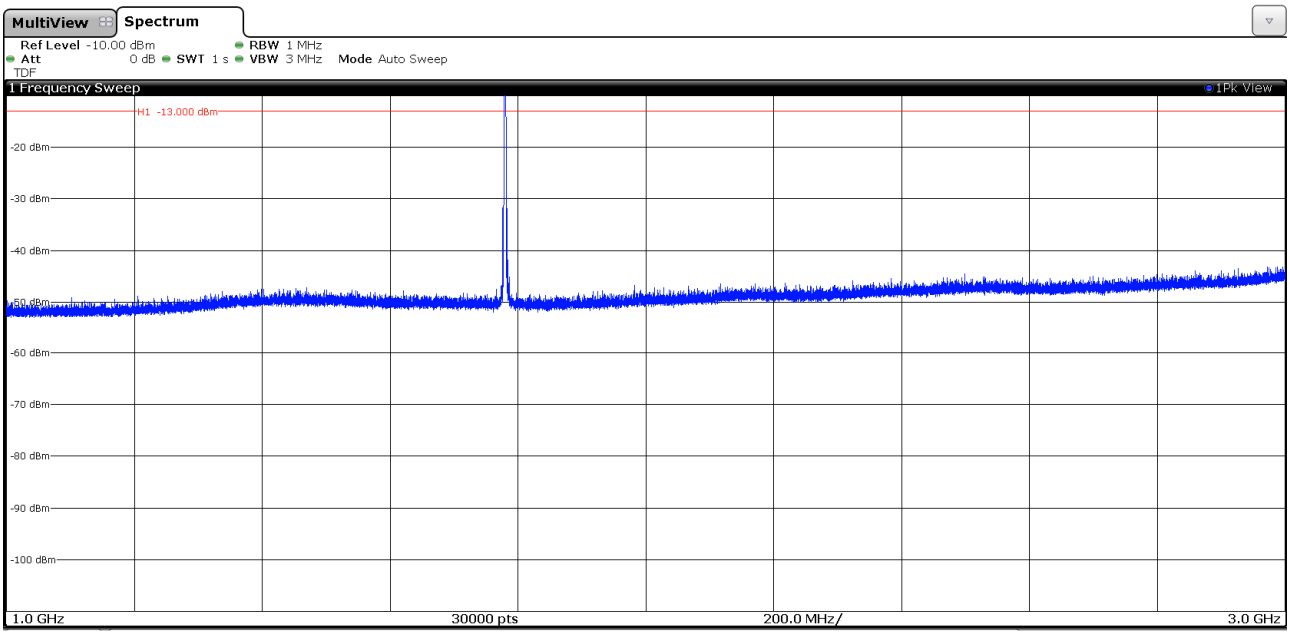

Note: The peak above the limit is the carrier frequency.

CHANNEL: MIDDLE




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

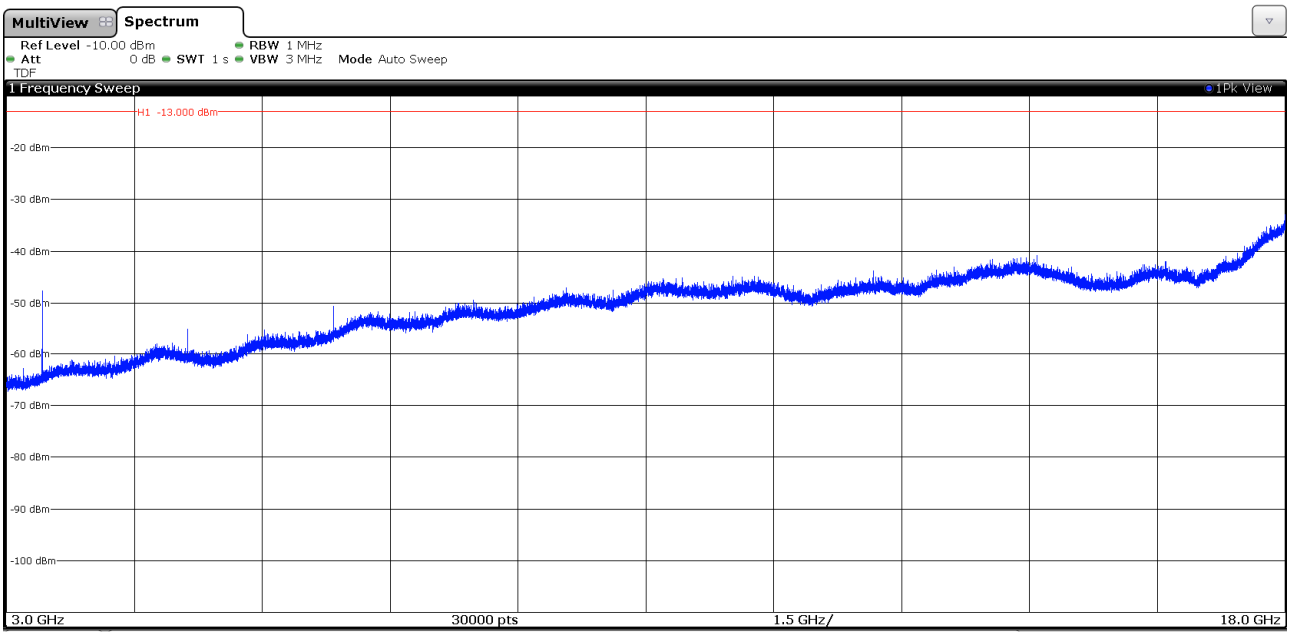
CHANNEL: HIGHEST



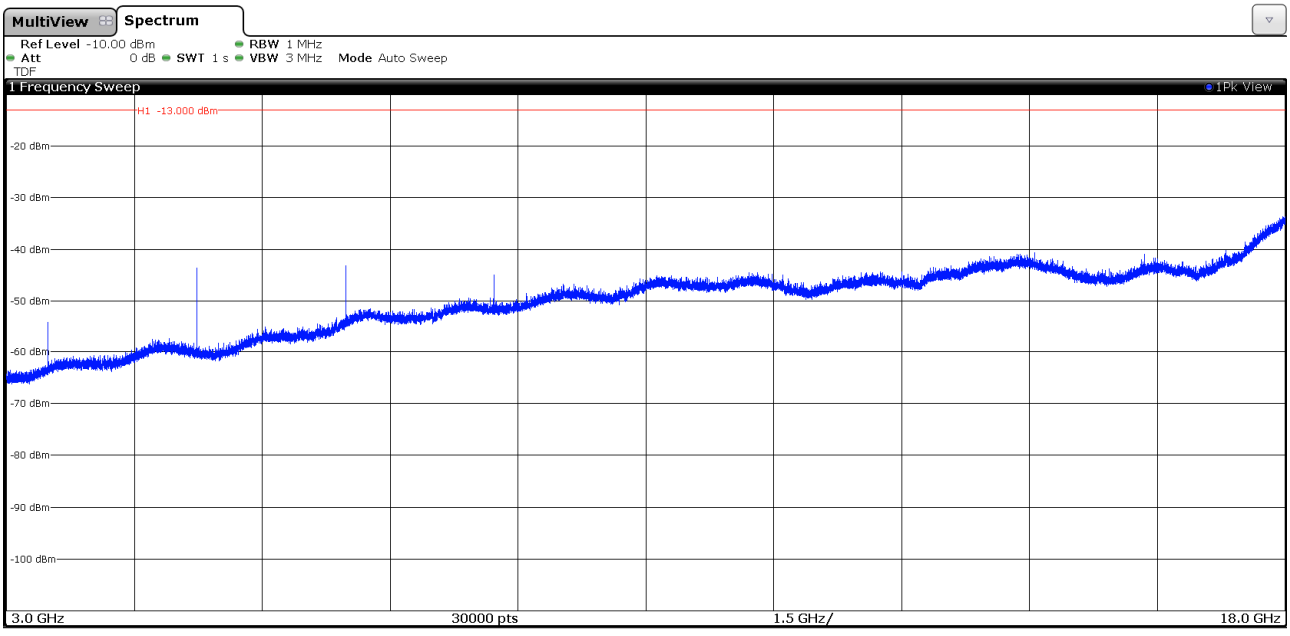

Note: The peak above the limit is the carrier frequency.

## NBIoT Band 66. Frequency range 3 GHz to 18 GHz

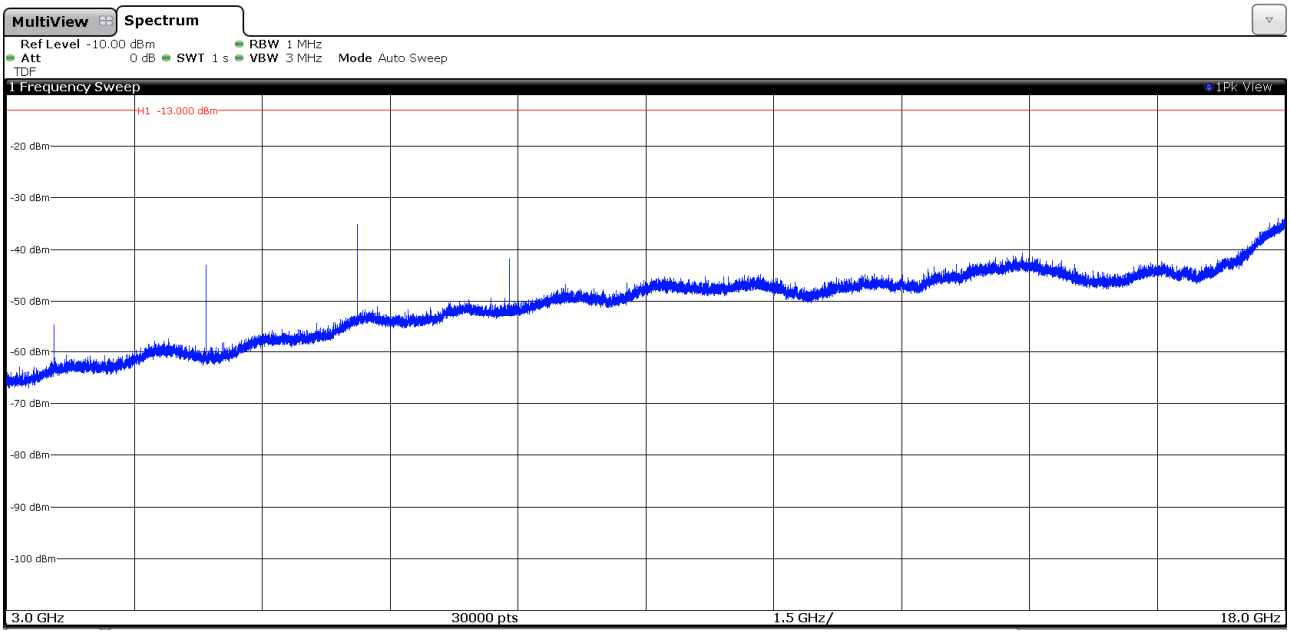
CHANNEL: LOWEST




CHANNEL: MIDDLE

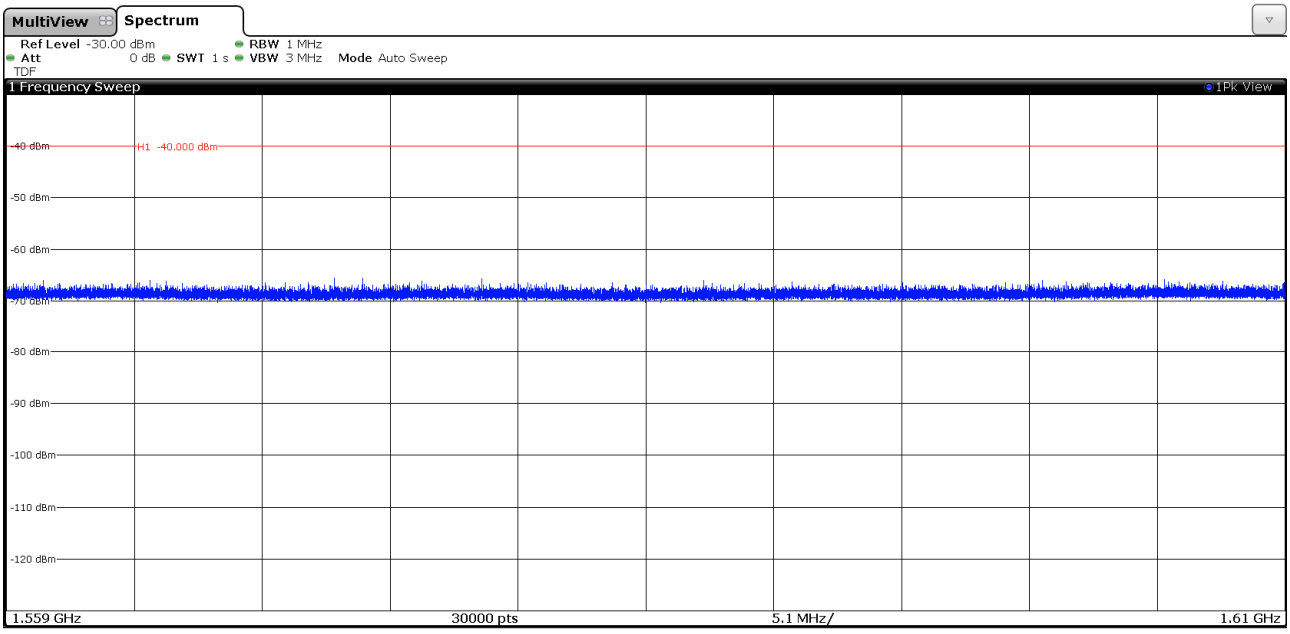


CHANNEL: HIGHEST

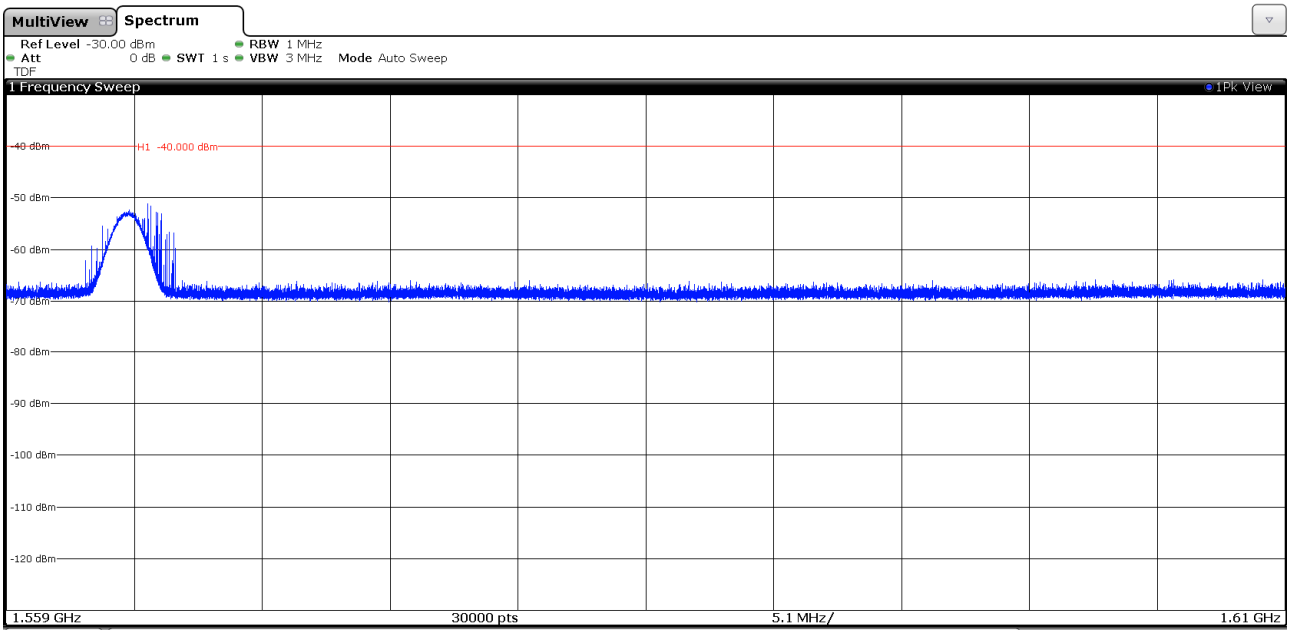



**NBIoT Band 13. Frequency range 1559 MHz to 1610 MHz.**

CHANNEL: LOWEST



## CHANNEL: MIDDLE




## CHANNEL: HIGHEST