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

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# TEST CONDITIONS

Power supply (V):

Vnominal = 3.8 Vdc

Type of power supply = DC Voltage from external power supply

Type of antenna = External antenna.

Declared Gain for antenna = +2.15 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.

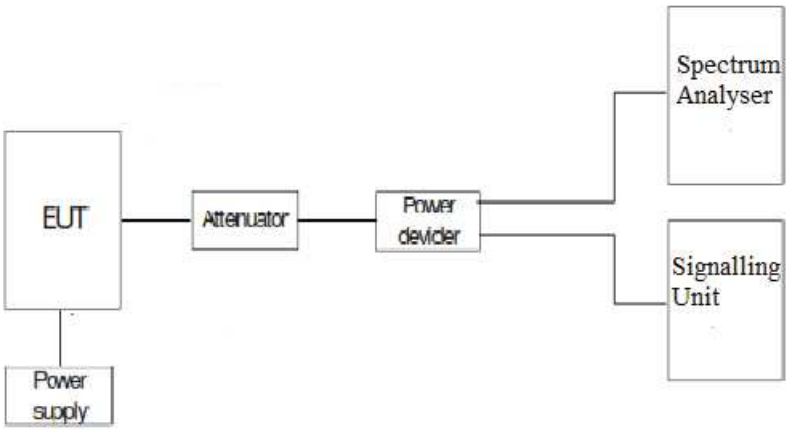
The maximum equivalent isotropically radiated power (e.i.r.p.) is calculated by adding the declared maximum antenna gain (dBi).

The 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

NBIoT. BAND 2.

| 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 | 22.59 | (*) |
| | | | | 1 | 47 | 22.56 | (*) |
| | | | 15 | 1 | 0 | 22.16 | (*) |
| | | | | 1 | 11 | 22.14 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.81 | (*) |
| | | | | 1 | 47 | 22.61 | (*) |
| | | | 15 | 1 | 0 | 22.08 | (*) |
| | | | | 1 | 11 | 22.05 | (*) |
| | | | | 3 | 0 | 21.6 | 4.19 |
| | | | | 3 | 6 | 21.56 | 4.21 |
| | | | | 6 | 0 | 21.15 | 5.94 |
| | | | | 6 | 6 | 21.16 | 5.96 |
| | | | | 12 | 0 | 20.6 | 6.15 |
| 26365 | 1882.5 | π/2 - BPSK | 3.75 | 1 | 0 | 22.7 | (*) |
| | | | | 1 | 47 | 22.69 | (*) |
| | | | 15 | 1 | 0 | 22.54 | (*) |
| | | | | 1 | 11 | 22.43 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.75 | (*) |
| | | | | 1 | 47 | 22.74 | (*) |
| | | | 15 | 1 | 0 | 22.39 | (*) |
| | | | | 1 | 11 | 22.36 | (*) |
| | | | | 3 | 0 | 21.94 | 4.18 |
| | | | | 3 | 6 | 22.26 | 4.13 |
| | | | | 6 | 0 | 21.37 | 5.91 |
| | | | | 6 | 6 | 21.33 | 5.86 |
| | | | | 12 | 0 | 20.71 | 6.12 |
| 26688 | 1914.8 | π/2 - BPSK | 3.75 | 1 | 0 | 22,45 | (*) |
| | | | | 1 | 47 | 22,48 | (*) |
| | | | 15 | 1 | 0 | 22.12 | (*) |
| | | | | 1 | 11 | 22.1 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.78 | (*) |
| | | | | 1 | 47 | 22.52 | (*) |
| | | | 15 | 1 | 0 | 22.04 | (*) |
| | | | | 1 | 11 | 21.99 | (*) |
| | | | | 3 | 0 | 21.57 | 4.13 |
| | | | | 3 | 6 | 21.94 | 4.03 |
| | | | | 6 | 0 | 21.11 | 5.84 |
| | | | | 6 | 6 | 21.1 | 5.83 |
| | | | | 12 | 0 | 20.54 | 6.07 |

(*): 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 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 | 22.46 | (*) |
| | | | | 1 | 47 | 22.47 | (*) |
| | | | 15 | 1 | 0 | 21.52 | (*) |
| | | | | 1 | 11 | 21.48 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.52 | (*) |
| | | | | 1 | 47 | 22.74 | (*) |
| | | | 15 | 1 | 0 | 21.4 | (*) |
| | | | | 1 | 11 | 21.36 | (*) |
| | | | | 3 | 0 | 20.91 | 4.23 |
| | | | | 3 | 6 | 21.95 | 4.24 |
| | | | | 6 | 0 | 21.16 | 5.98 |
| | | | | 6 | 6 | 21.18 | 6.03 |
| | | | | 12 | 0 | 20.62 | 6.35 |
| 26365 | 1882.5 | π/2 - BPSK | 3.75 | 1 | 0 | 22.74 | (*) |
| | | | | 1 | 47 | 22.76 | (*) |
| | | | 15 | 1 | 0 | 22.4 | (*) |
| | | | | 1 | 11 | 22.43 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.79 | (*) |
| | | | | 1 | 47 | 22.8 | (*) |
| | | | 15 | 1 | 0 | 22.42 | (*) |
| | | | | 1 | 11 | 22.41 | (*) |
| | | | | 3 | 0 | 21.94 | 4.17 |
| | | | | 3 | 6 | 22.28 | 4.14 |
| | | | | 6 | 0 | 21.32 | 5.9 |
| | | | | 6 | 6 | 21.35 | 5.83 |
| | | | | 12 | 0 | 20.74 | 6.41 |
| 26688 | 1914.8 | π/2 - BPSK | 3.75 | 1 | 0 | 22.7 | (*) |
| | | | | 1 | 47 | 22.69 | (*) |
| | | | 15 | 1 | 0 | 21.46 | (*) |
| | | | | 1 | 11 | 21.4 | (*) |
| | | π/4 - QPSK | 3.75 | 1 | 0 | 22.72 | (*) |
| | | | | 1 | 47 | 22.8 | (*) |
| | | | 15 | 1 | 0 | 21.38 | (*) |
| | | | | 1 | 11 | 21.33 | (*) |
| | | | | 3 | 0 | 20.91 | 4.12 |
| | | | | 3 | 6 | 21.31 | 4.08 |
| | | | | 6 | 0 | 20.45 | 5.82 |
| | | | | 6 | 6 | 20.45 | 5.69 |
| | | | | 12 | 0 | 19.87 | 6.27 |

(*): 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 2.

| 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) |
|---|---|---|---|---|
| Lowest | 22.81 | 2.15 | 24.96 | 22.81 |
| Middle | 22.75 | 2.15 | 24.90 | 22.75 |
| Highest | 22.78 | 2.15 | 24.93 | 22.78 |
| Measurement uncertainty (dB) | <±0.941 | | | |

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) |
|---|---|---|---|---|
| Lowest | 22.74 | 2.15 | 24.89 | 22.74 |
| Middle | 22.80 | 2.15 | 24.95 | 22.80 |
| Highest | 22.80 | 2.15 | 24.95 | 22.80 |
| Measurement uncertainty (dB) | <±0.941 | | | |

Verdict: PASS

PEAK-TO-AVERAGE POWER RATIO (PAPR).

NBIoT BAND 2.

Preliminary measurements determined that 12 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 | 20.65 dBm |
| Peak | 27.29 dBm |
| Crest | 6.64 dB |
| 10 % | 2.59 dB |
| 1 % | 4.85 dB |
| .1 % | 6.15 dB |
| .01 % | 6.60 dB |

Channel Middle:


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

| | Trace 1 |
|---|---|
| Mean | 20.44 dBm |
| Peak | 27.00 dBm |
| Crest | 6.57 dB |
| 10 % | 2.62 dB |
| 1 % | 4.87 dB |
| .1 % | 6.12 dB |
| .01 % | 6.48 dB |

Channel High:

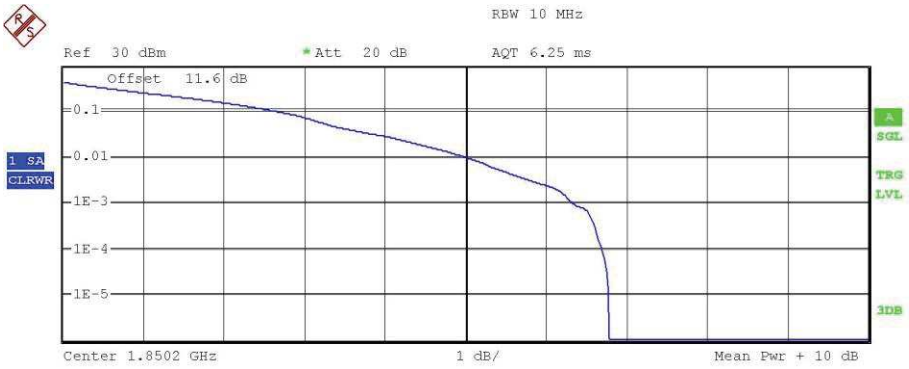

**Complementary Cumulative Distribution Function**
**NOF samples: 100000, Usable BW: 11.2MHz**

| | Trace 1 |
|---|---|
| Mean | 20.53 dBm |
| Peak | 27.04 dBm |
| Crest | 6.51 dB |
| 10 % | 2.64 dB |
| 1 % | 4.90 dB |
| .1 % | 6.07 dB |
| .01 % | 6.42 dB |

NBIoT BAND 25.

Preliminary measurements determined that 12 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

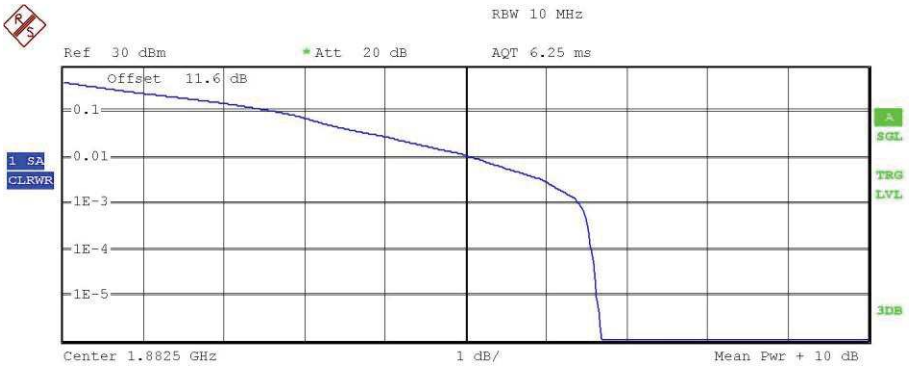
Channel Low:




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

| | Trace 1 |
|---|---|
| Mean | 20.58 dBm |
| Peak | 27.36 dBm |
| Crest | 6.78 dB |
| 10 % | 2.69 dB |
| 1 % | 5.03 dB |
| .1 % | 6.35 dB |
| .01 % | 6.70 dB |

Channel Middle:




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

| | Trace 1 |
|---|---|
| Mean | 20.33 dBm |
| Peak | 27.01 dBm |
| Crest | 6.69 dB |
| 10 % | 2.68 dB |
| 1 % | 5.10 dB |
| .1 % | 6.41 dB |
| .01 % | 6.57 dB |

Channel High:


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

| | Trace 1 |
|---|---|
| Mean | 20.57 dBm |
| Peak | 27.13 dBm |
| Crest | 6.56 dB |
| 10 % | 2.68 dB |
| 1 % | 5.02 dB |
| .1 % | 6.27 dB |
| .01 % | 6.46 dB |

# 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.

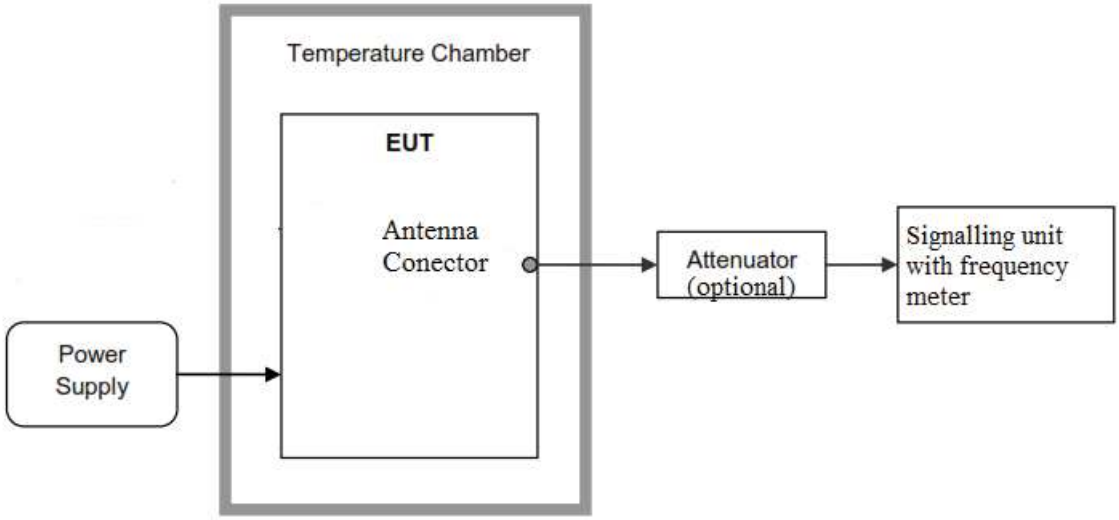
The EUT was set in “Radio Resource Control (RRC) mode” in the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case LTE mode for conducted power was used for the test.

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

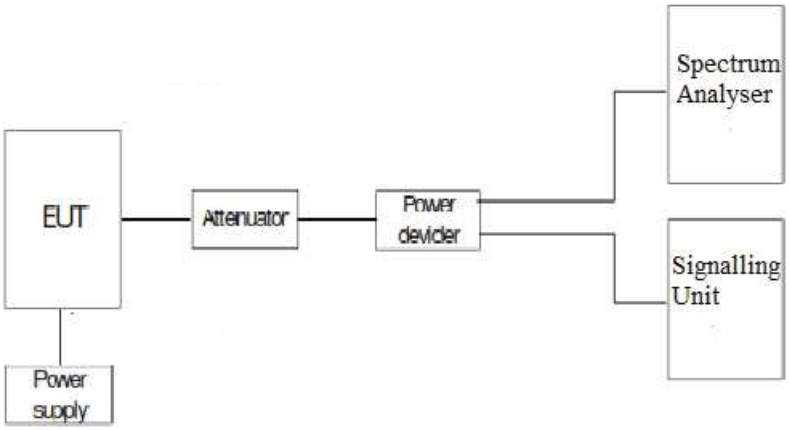
The reference point measurements were made at the RF output terminals of the EUT using an attenuator. power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

TEST SETUP:

1. Frequency Tolerance:




3. Reference Frequency Points fL and fH:



RESULTS:

Frequency stability over temperature variations.

NBIoT Band 25. π/4 - QPSK modulation. 1 tone 3.75 kHz. Channel: 1882.5 MHz.

| Temperature (ºC) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|
| +50 | 3.81 | 0.002023904 |
| +40 | 5.21 | 0.002767596 |
| +30 | 4.32 | 0.002294821 |
| +20 | 4.73 | 0.002512616 |
| +10 | 4.96 | 0.002634794 |
| 0 | 5.61 | 0.00298008 |
| -10 | -1.02 | -0.000541833 |
| -20 | -0.58 | -0.000308101 |
| -30 | 1.9 | 0.001009296 |

| | |
|---|---|
| Measurement uncertainty(Hz) | <±222 |

Frequency stability over voltage variations.

| Battery Supply voltage | Voltage (V) | Frequency Error (Hz) | Frequency Error (ppm) |
|---|---|---|---|
| Vmax | 4.2 | 5.88 | 0.003123506 |
| Vmin | 3.2 | -4.48 | -0.002379814 |

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

| | |
|---|---|
| *f*L (MHz) | 1850.0510 |
| *fH (MHz)* | 1914.9450 |

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

| | |
|---|---|
| *f*L (MHz) | 1850.050991 |
| *fH (MHz)* | 1914.945004 |

Verdict: PASS

# Modulation Characteristics

SPECIFICATION:

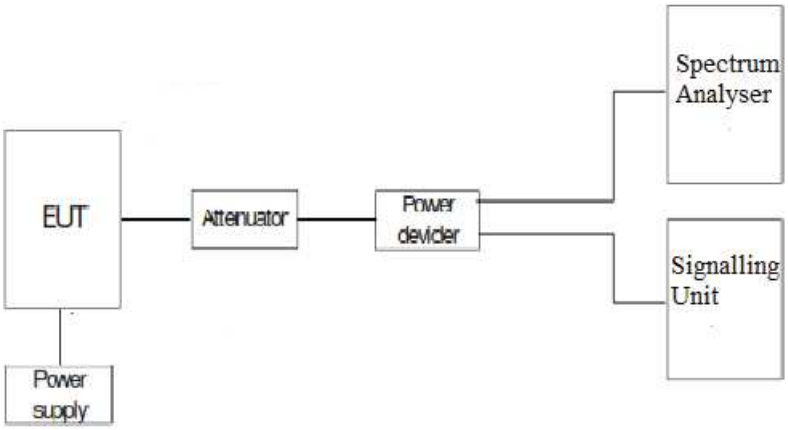
FCC §2.1047

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.

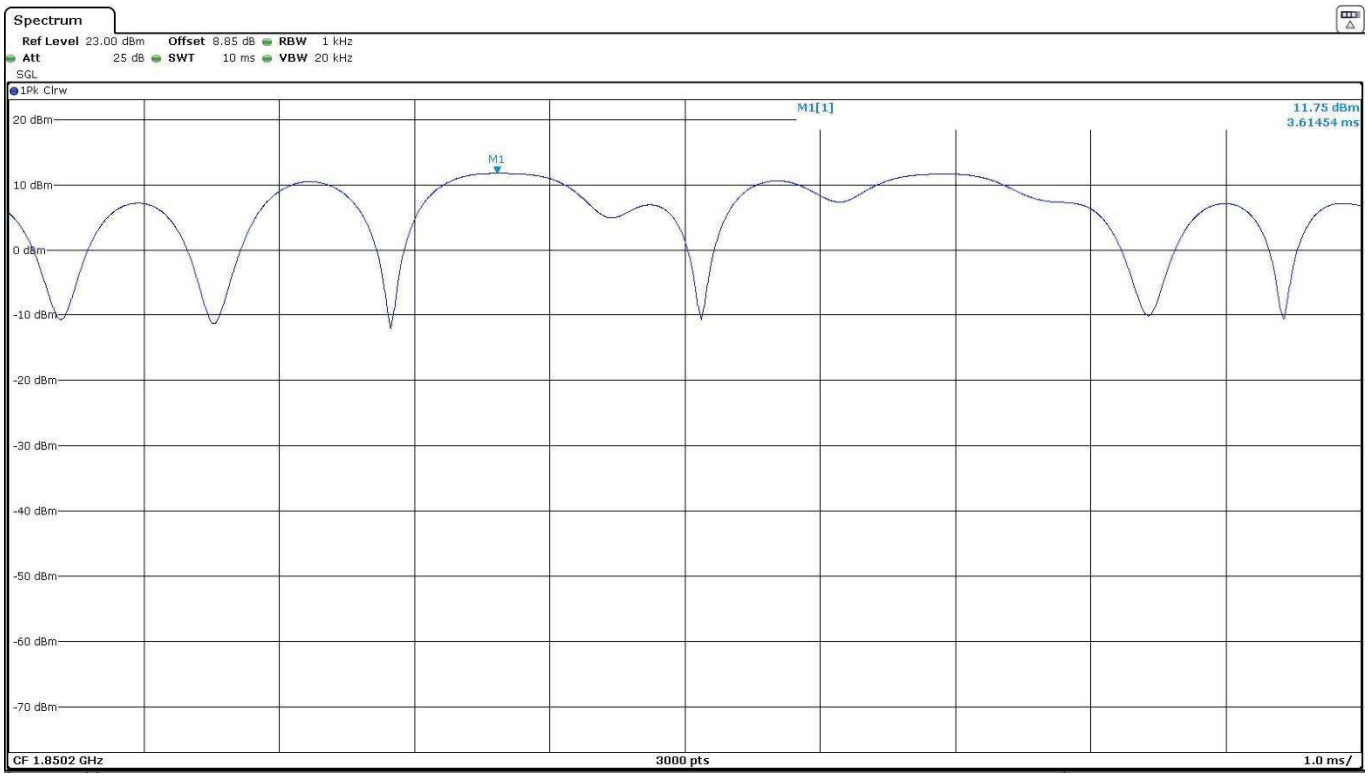
TEST SETUP:



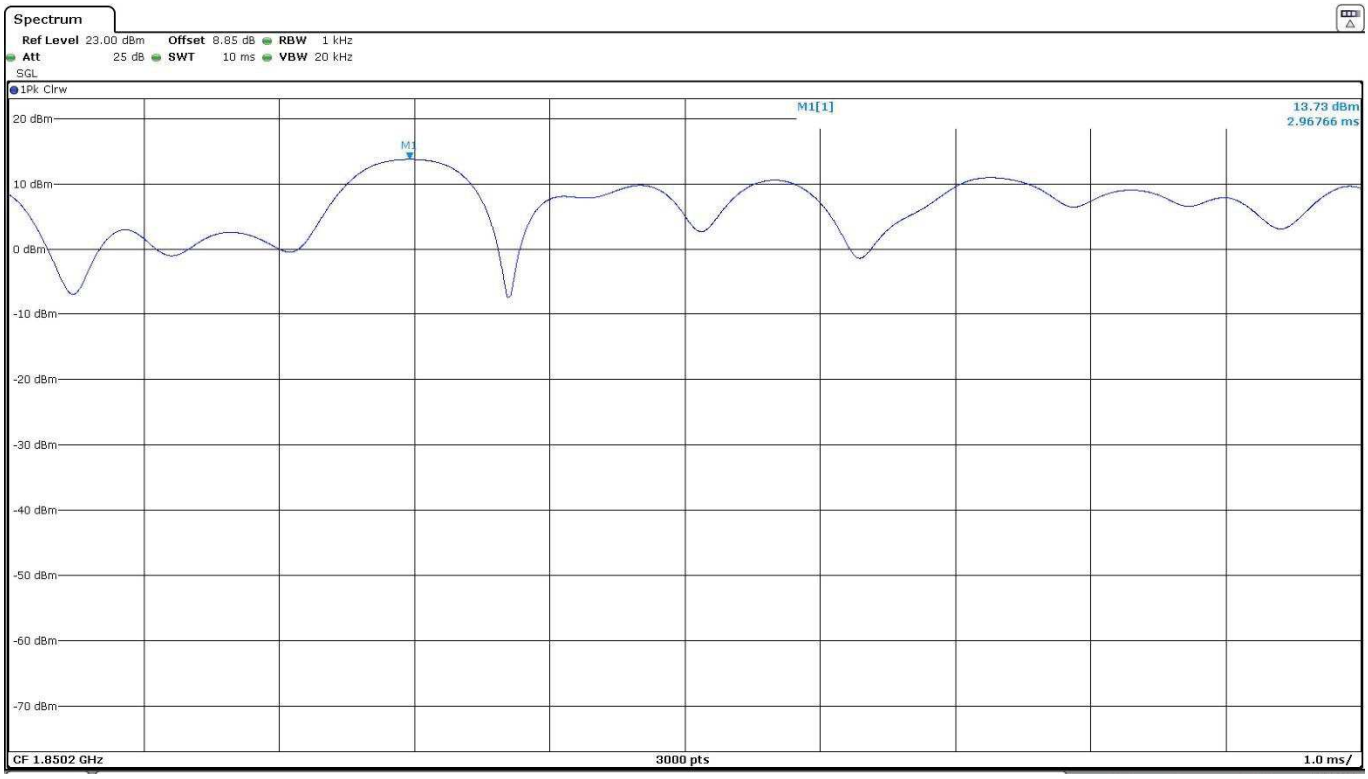
RESULTS:

The following plots show the modulation schemes in the EUT.

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




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



# Occupied Bandwidth

SPECIFICATION:

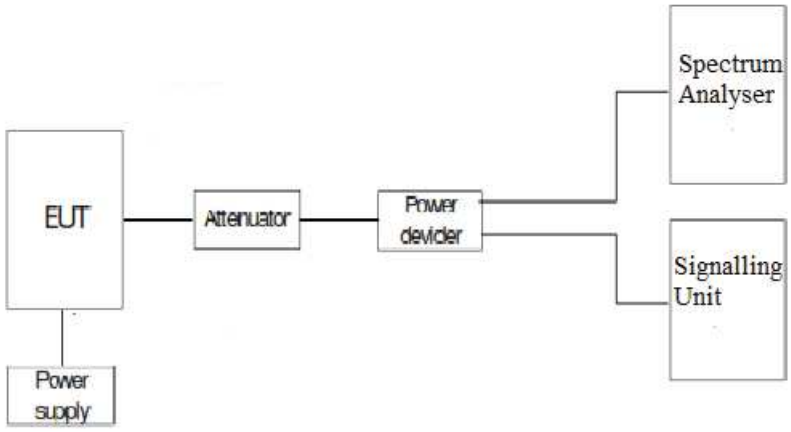
FCC §2.1049. Measurements required: Occupied bandwidth.

RSS-Gen Clause 6.7.

METHOD:

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

TEST SETUP:



NBIoT BAND 25.

Tone 3.75 kHz. π/2 - BPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 46.333 | 46.700 | 48.666 |
| -26 dBc bandwidth (kHz) | 42.467 | 43.133 | 43.067 |
| Measurement uncertainty (kHz) | <±0.27 | | |

Tone 3.75 kHz. π/4 - QPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 48.260 | 49.467 | 49.067 |
| -26 dBc bandwidth (kHz) | 42.600 | 43.200 | 42.867 |
| Measurement uncertainty (kHz) | <±0.27 | | |

Tone 15 kHz. π/2 - BPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 74.583 | 78.600 | 80.933 |
| -26 dBc bandwidth (kHz) | 99.250 | 93.467 | 101.748 |
| Measurement uncertainty (kHz) | <±0.28 | | |

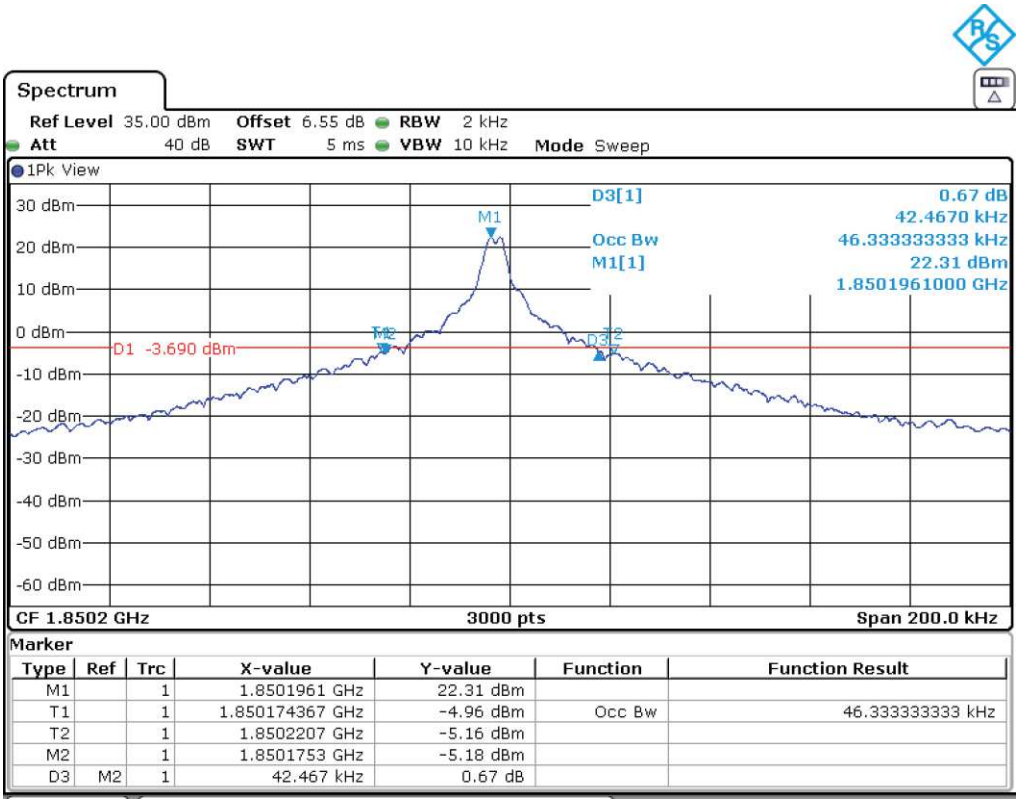
12 Tones 15 kHz. π/4 - QPSK MODULATION

| Channel | Lowest | Middle | Highest |
|---|---|---|---|
| 99% Occupied bandwidth (kHz) | 187.600 | 187.333 | 187.467 |
| -26 dBc bandwidth (kHz) | 268.300 | 295.160 | 268.930 |
| Measurement uncertainty (kHz) | <±0.65 | | |

RESULTS:
NBIoT BAND 25.

Tone 3.75 kHz. π/2 - BPSK MODULATION

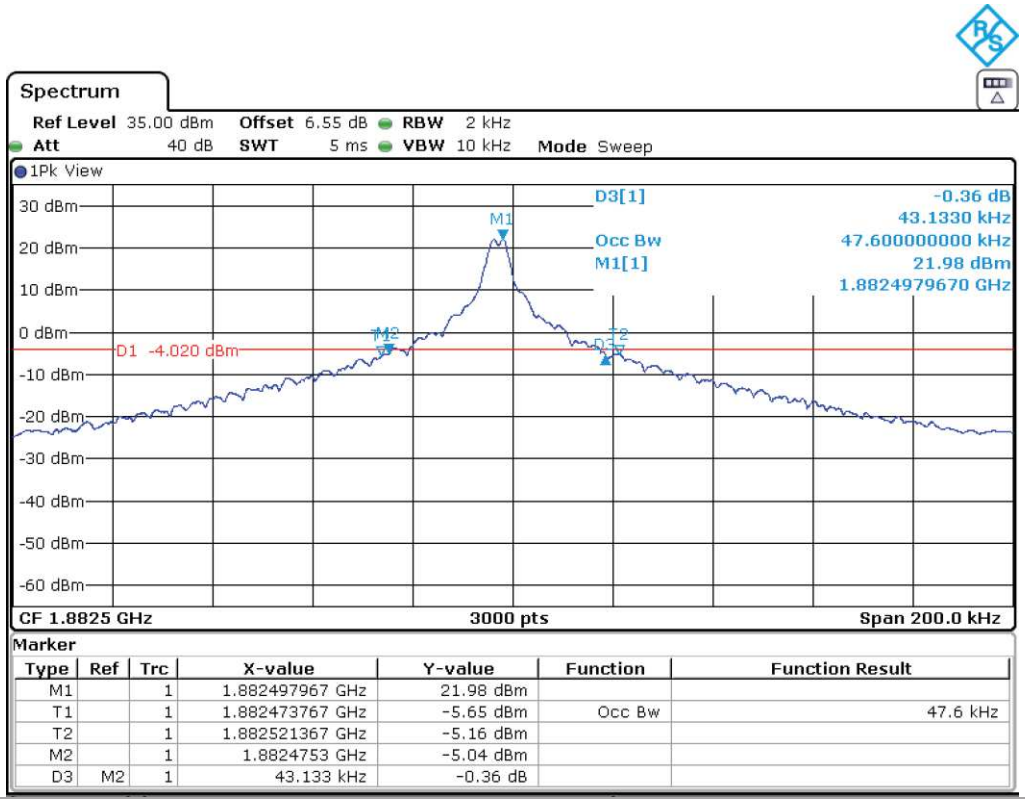
Lowest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.8501961 GHz | 22.31 dBm | | |
| T1 | | 1 | 1.850174367 GHz | -4.96 dBm | Occ Bw | 46.333333333 kHz |
| T2 | | 1 | 1.8502207 GHz | -5.16 dBm | | |
| M2 | | 1 | 1.8501753 GHz | -5.18 dBm | | |
| D3 | M2 | 1 | 42.467 kHz | 0.67 dB | | |

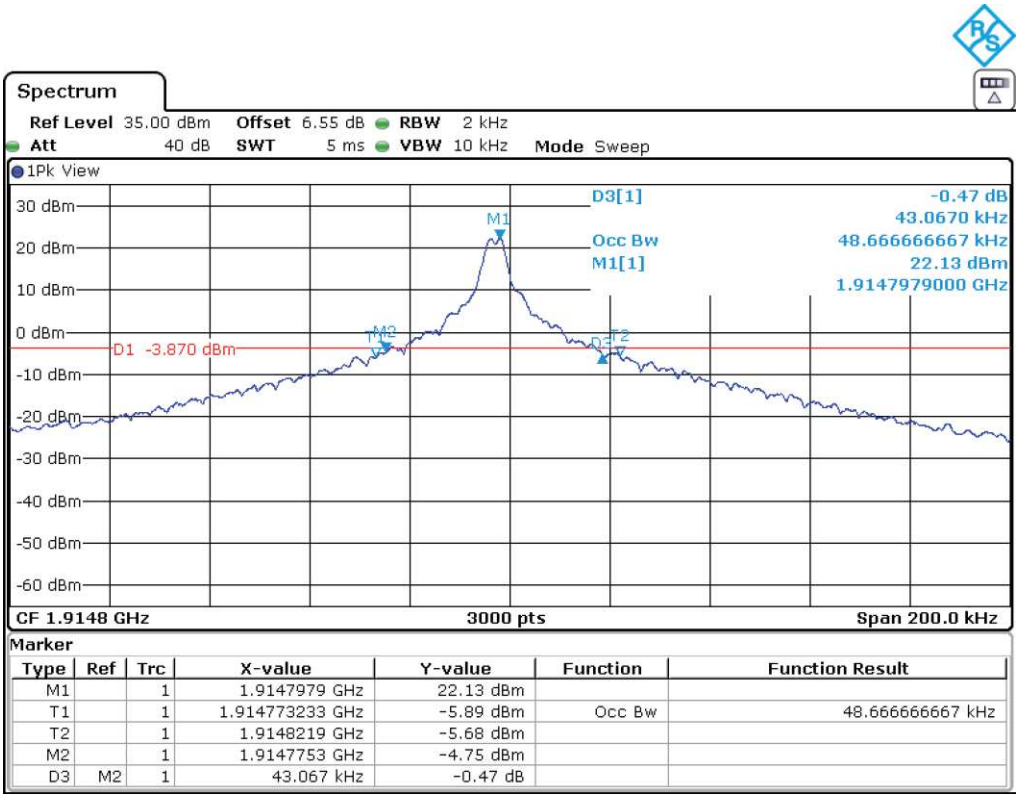
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.882497967 GHz | 21.98 dBm | | |
| T1 | | 1 | 1.882473767 GHz | -5.65 dBm | Occ Bw | 47.6 kHz |
| T2 | | 1 | 1.882521367 GHz | -5.16 dBm | | |
| M2 | | 1 | 1.8824753 GHz | -5.04 dBm | | |
| D3 | M2 | 1 | 43.133 kHz | -0.36 dB | | |

Highest Channel

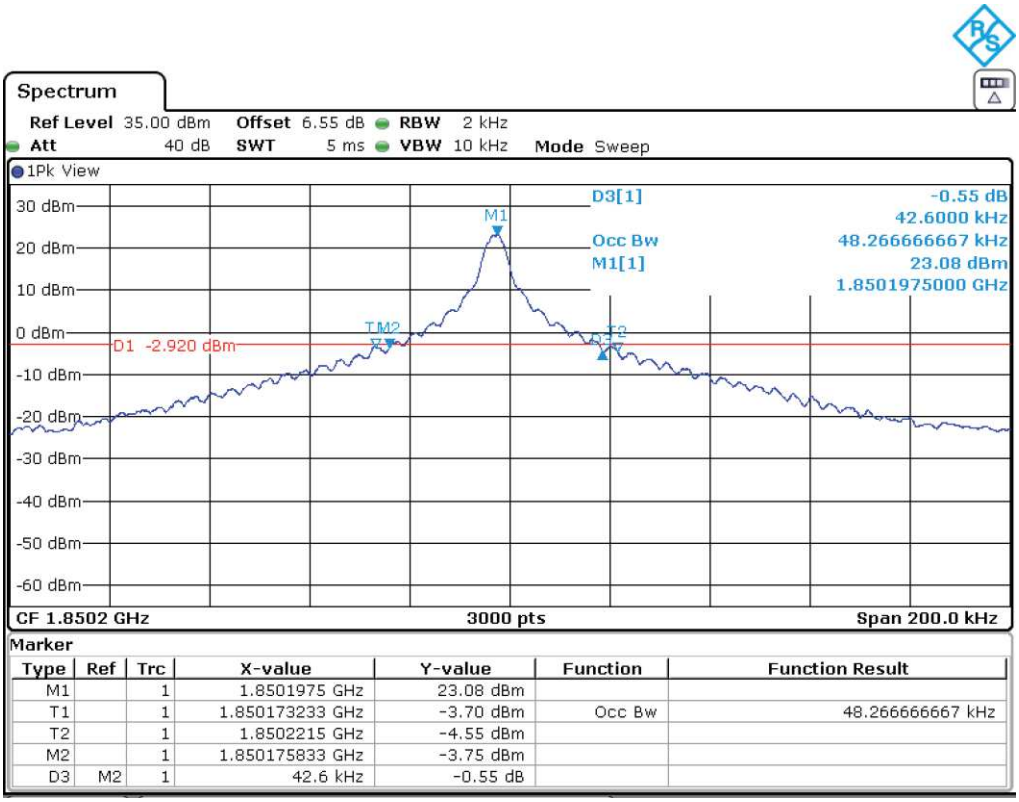



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.9147979 GHz | 22.13 dBm | | |
| T1 | | 1 | 1.914773233 GHz | -5.89 dBm | Occ Bw | 48.666666667 kHz |
| T2 | | 1 | 1.9148219 GHz | -5.68 dBm | | |
| M2 | | 1 | 1.9147753 GHz | -4.75 dBm | | |
| D3 | M2 | 1 | 43.067 kHz | -0.47 dB | | |

Tone 3.75 kHz. π/4 - QPSK MODULATION

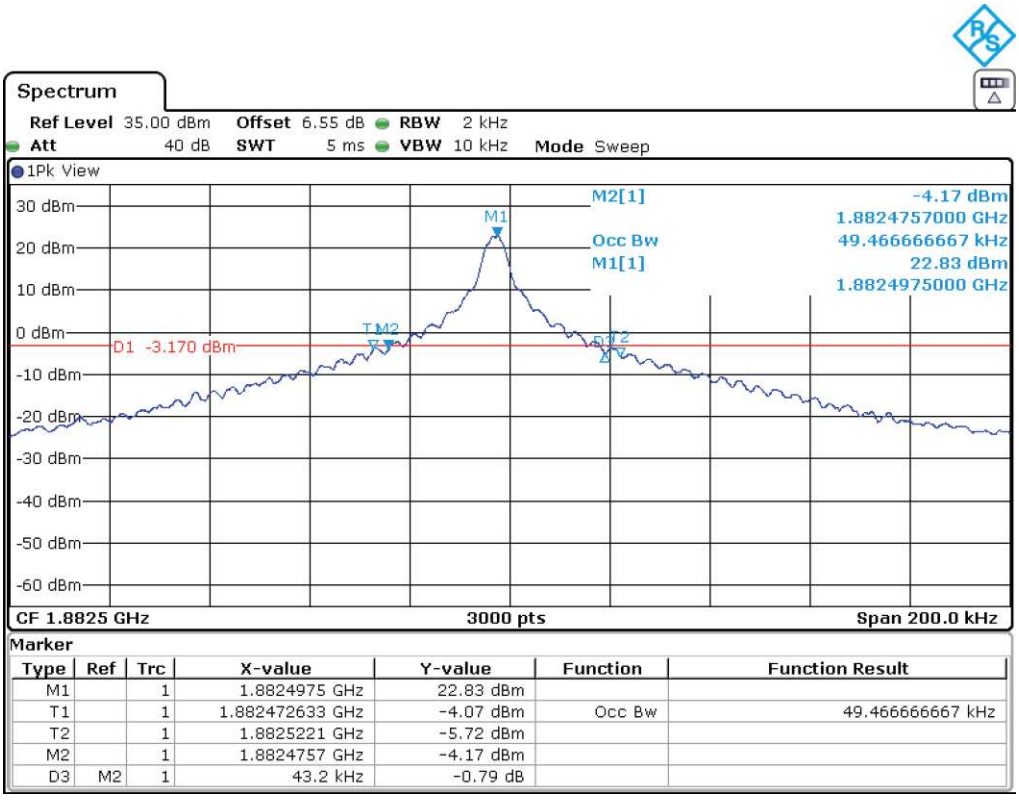
Lowest Channel



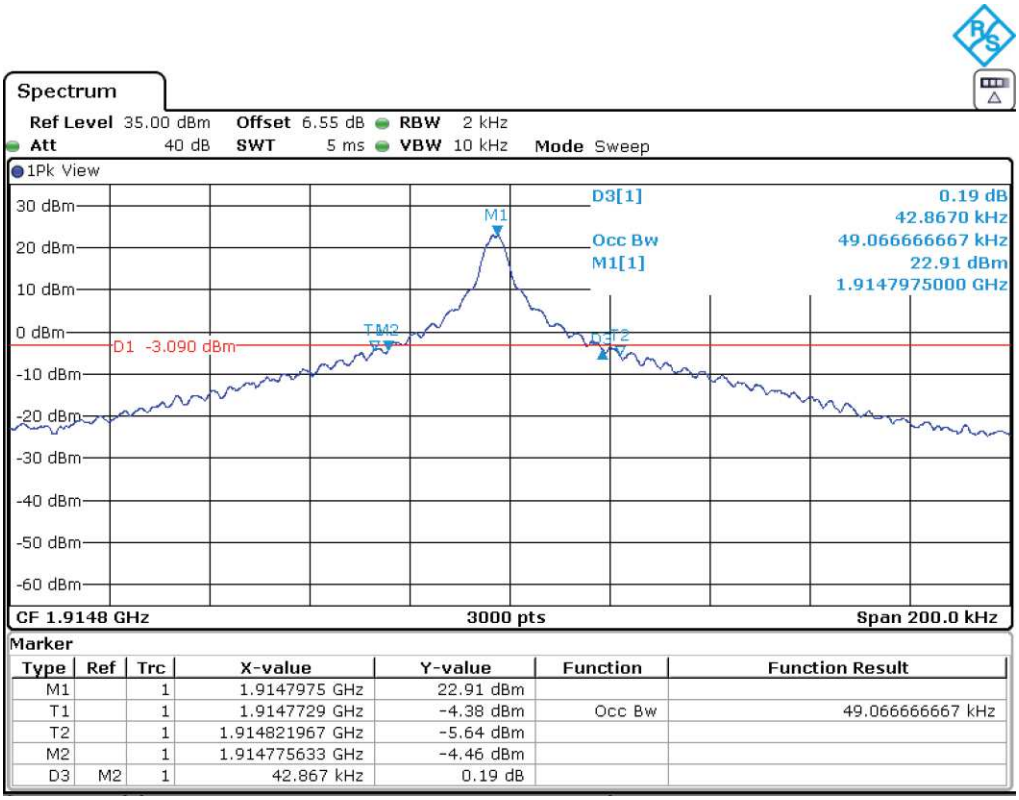

Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.8501975 GHz | 23.08 dBm | | |
| T1 | | 1 | 1.850173233 GHz | -3.70 dBm | Occ Bw | 48.266666667 kHz |
| T2 | | 1 | 1.8502215 GHz | -4.55 dBm | | |
| M2 | | 1 | 1.850175833 GHz | -3.75 dBm | | |
| D3 | M2 | 1 | 42.6 kHz | -0.55 dB | | |

Middle Channel

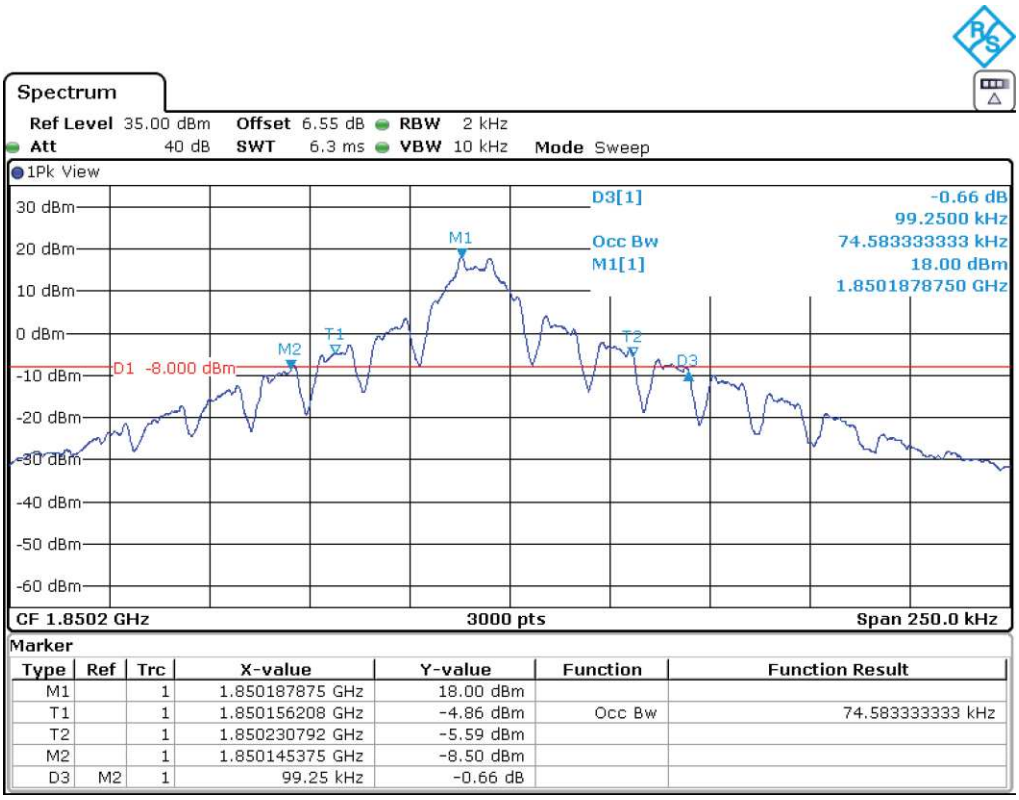



Highest Channel



Tone 15 kHz. π/2 - BPSK MODULATION

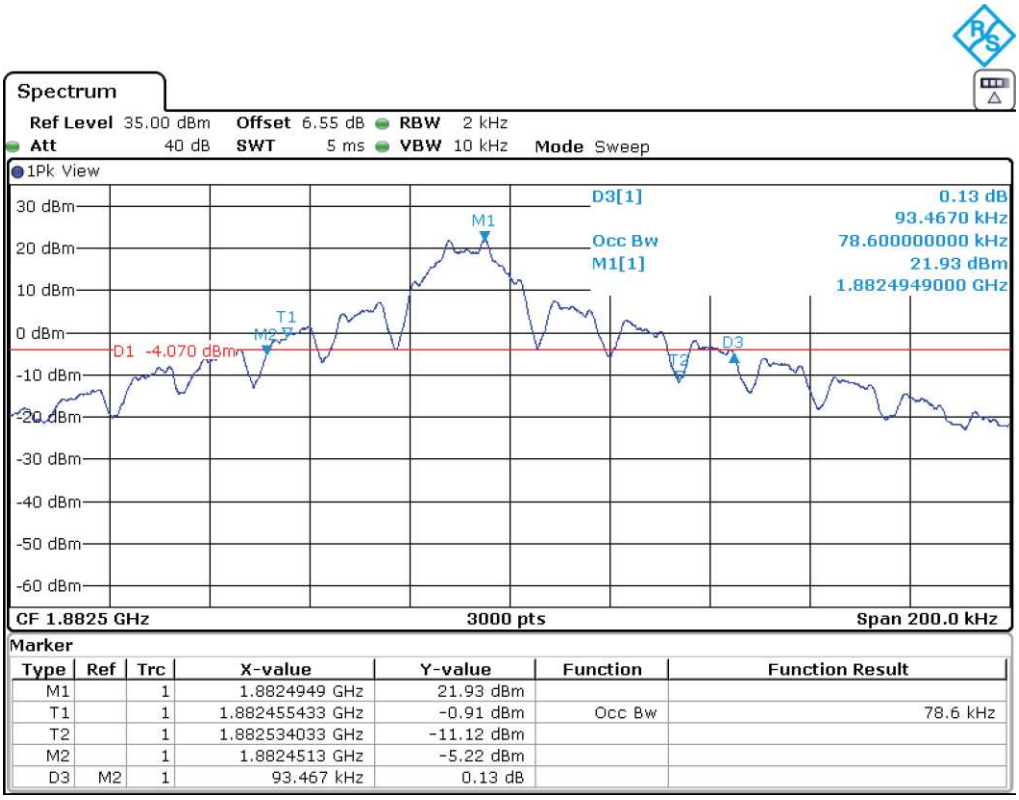
Lowest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.850187875 GHz | 18.00 dBm | | |
| T1 | | 1 | 1.850156208 GHz | -4.86 dBm | Occ Bw | 74.583333333 kHz |
| T2 | | 1 | 1.850230792 GHz | -5.59 dBm | | |
| M2 | | 1 | 1.850145375 GHz | -8.50 dBm | | |
| D3 | M2 | 1 | 99.25 kHz | -0.66 dB | | |

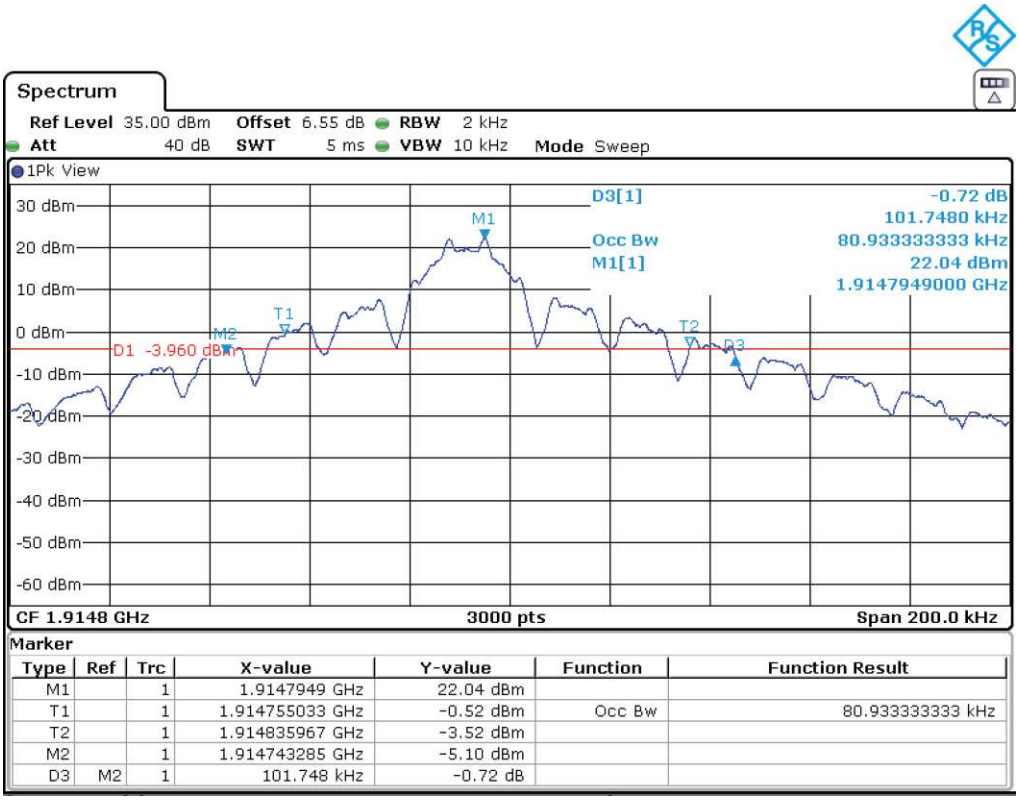
Middle Channel




Marker

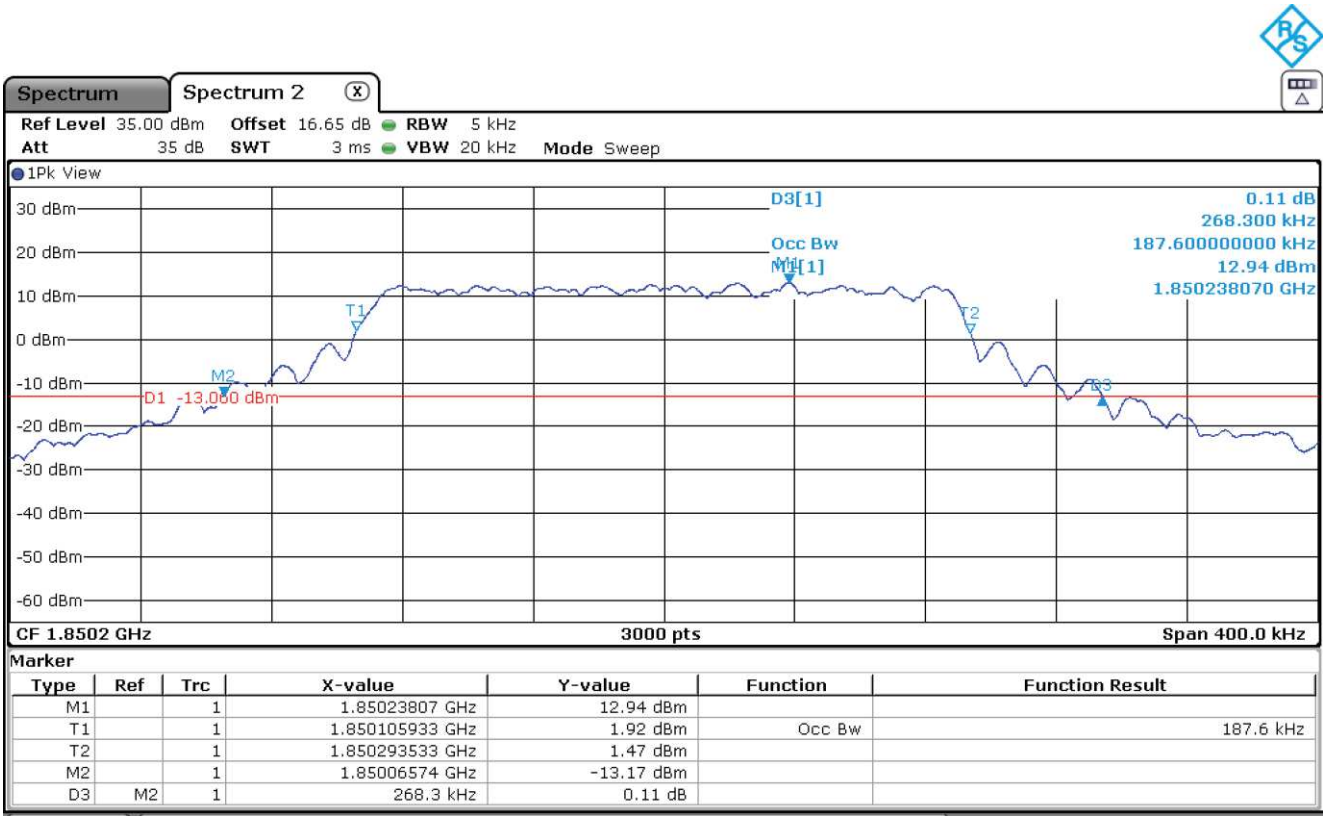
| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.8824949 GHz | 21.93 dBm | | |
| T1 | | 1 | 1.882455433 GHz | -0.91 dBm | Occ Bw | 78.6 kHz |
| T2 | | 1 | 1.882534033 GHz | -11.12 dBm | | |
| M2 | | 1 | 1.8824513 GHz | -5.22 dBm | | |
| D3 | M2 | 1 | 93.467 kHz | 0.13 dB | | |

Highest Channel

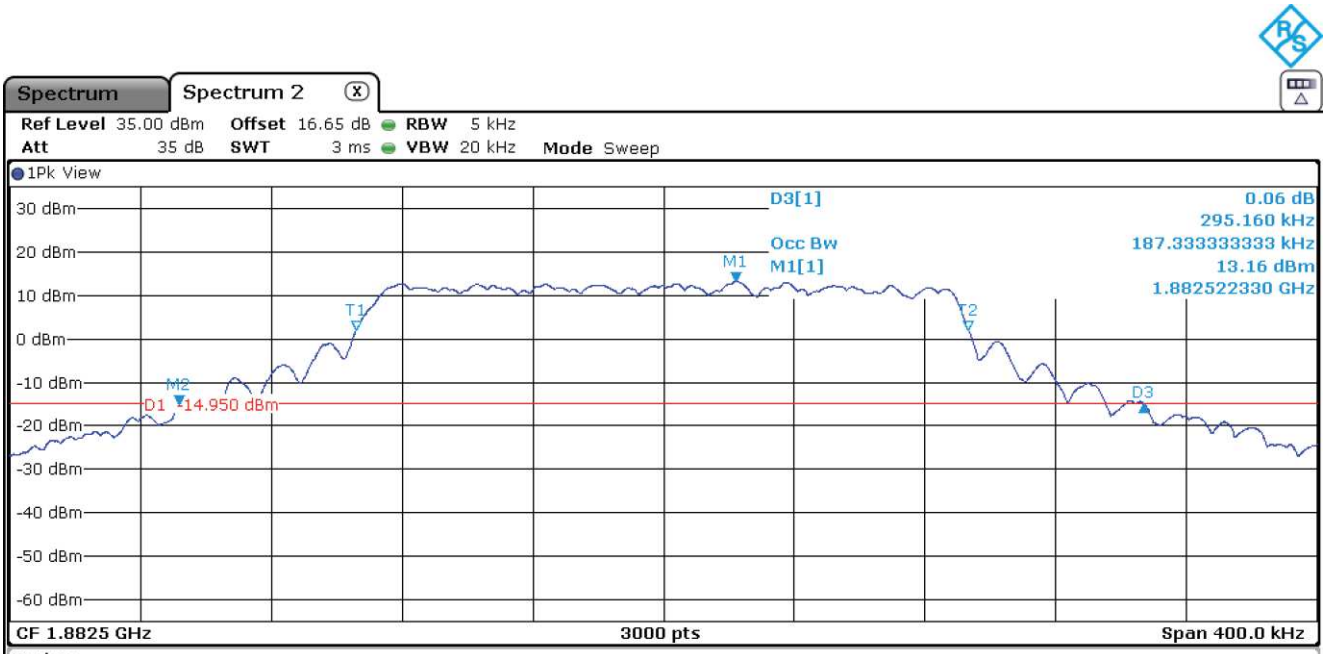



12 Tones 15 kHz. π/4 - QPSK MODULATION

Lowest Channel



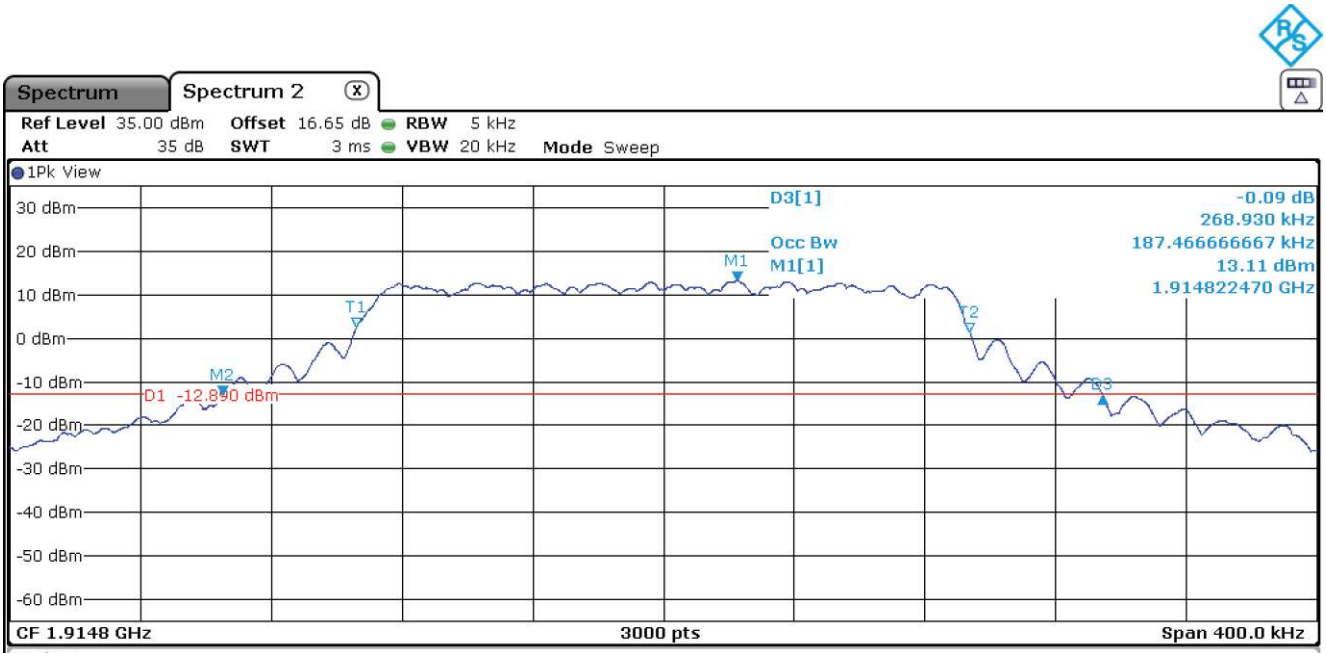
Middle Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.88252233 GHz | 13.16 dBm | | |
| T1 | | 1 | 1.882405933 GHz | 1.92 dBm | Occ Bw | 187.333333333 kHz |
| T2 | | 1 | 1.882593267 GHz | 2.03 dBm | | |
| M2 | | 1 | 1.88235196 GHz | -15.05 dBm | | |
| D3 | M2 | 1 | 295.16 kHz | 0.06 dB | | |

Highest Channel




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 1.91482247 GHz | 13.11 dBm | | |
| T1 | | 1 | 1.914706067 GHz | 2.43 dBm | Occ Bw | 187.466666667 kHz |
| T2 | | 1 | 1.914893533 GHz | 1.51 dBm | | |
| M2 | | 1 | 1.9146654 GHz | -13.02 dBm | | |
| D3 | M2 | 1 | 268.93 kHz | -0.09 dB | | |

# 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 9 GHz for NBIoT Band 5 and 26.

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.

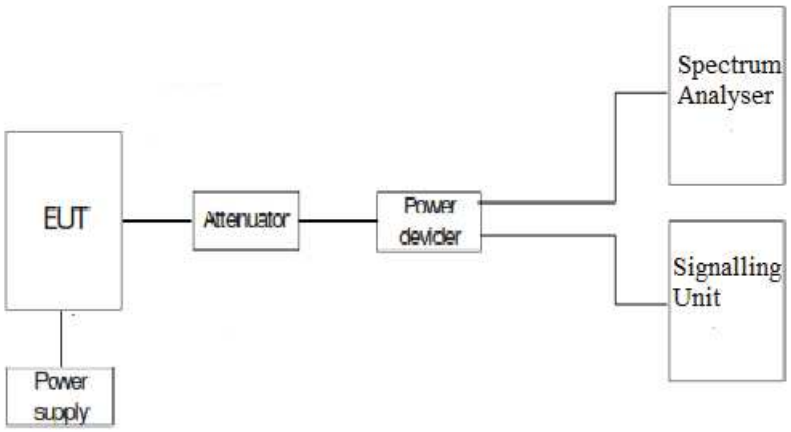
Measurement Limit**:**

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:



NBIoT BAND 25 (Tone 3.75 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST

All peaks are more than 20 dB below the limit.

2. CHANNEL: MIDDLE

All peaks are more than 20 dB below the limit.

3. CHANNEL: HIGHEST
All peaks are more than 20 dB below the limit.

NBIoT BAND 25 (Tone 15 kHz. π/4 - QPSK MODULATION)

1. CHANNEL: LOWEST

All peaks are more than 20 dB below the limit.

2. CHANNEL: MIDDLE

All peaks are more than 20 dB below the limit.

3. CHANNEL: HIGHEST

All peaks are more than 20 dB below the limit.

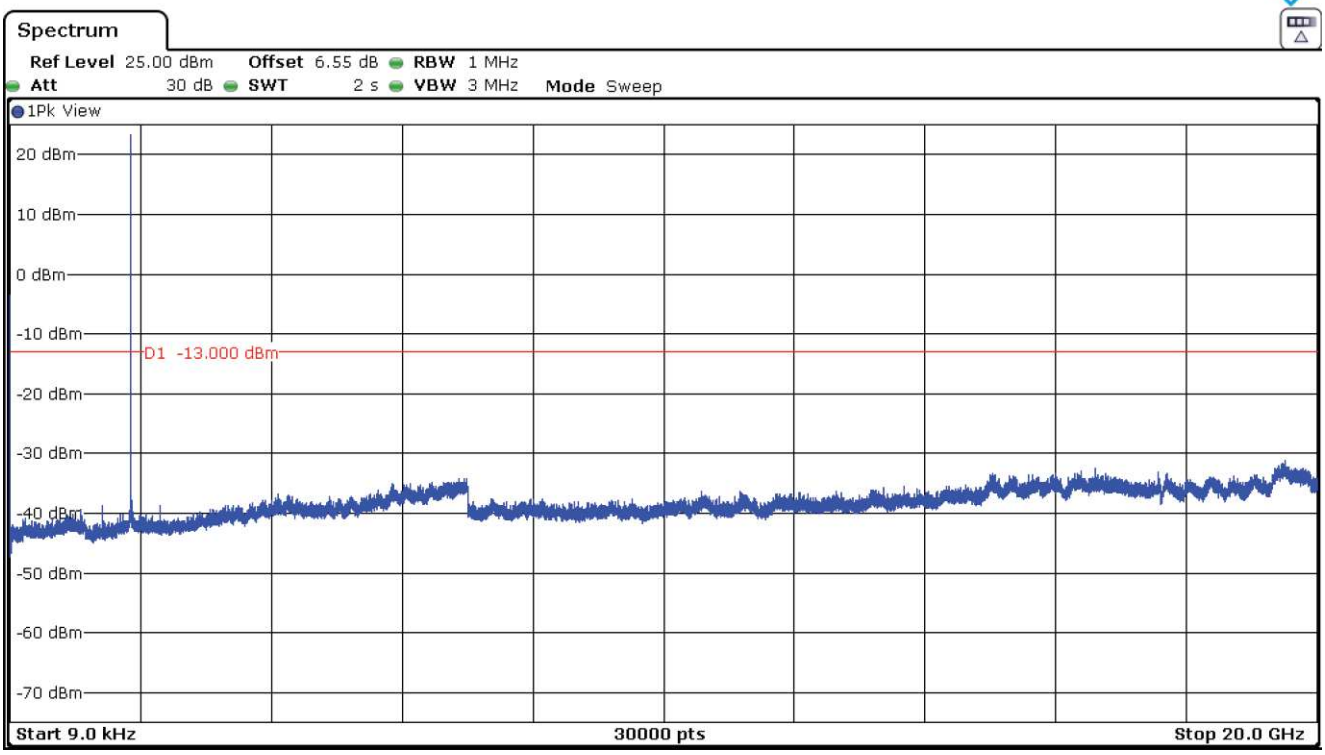
Measurement uncertainty (dB): < ± 2.76

Verdict: PASS

RESULTS (see plots in next pages)

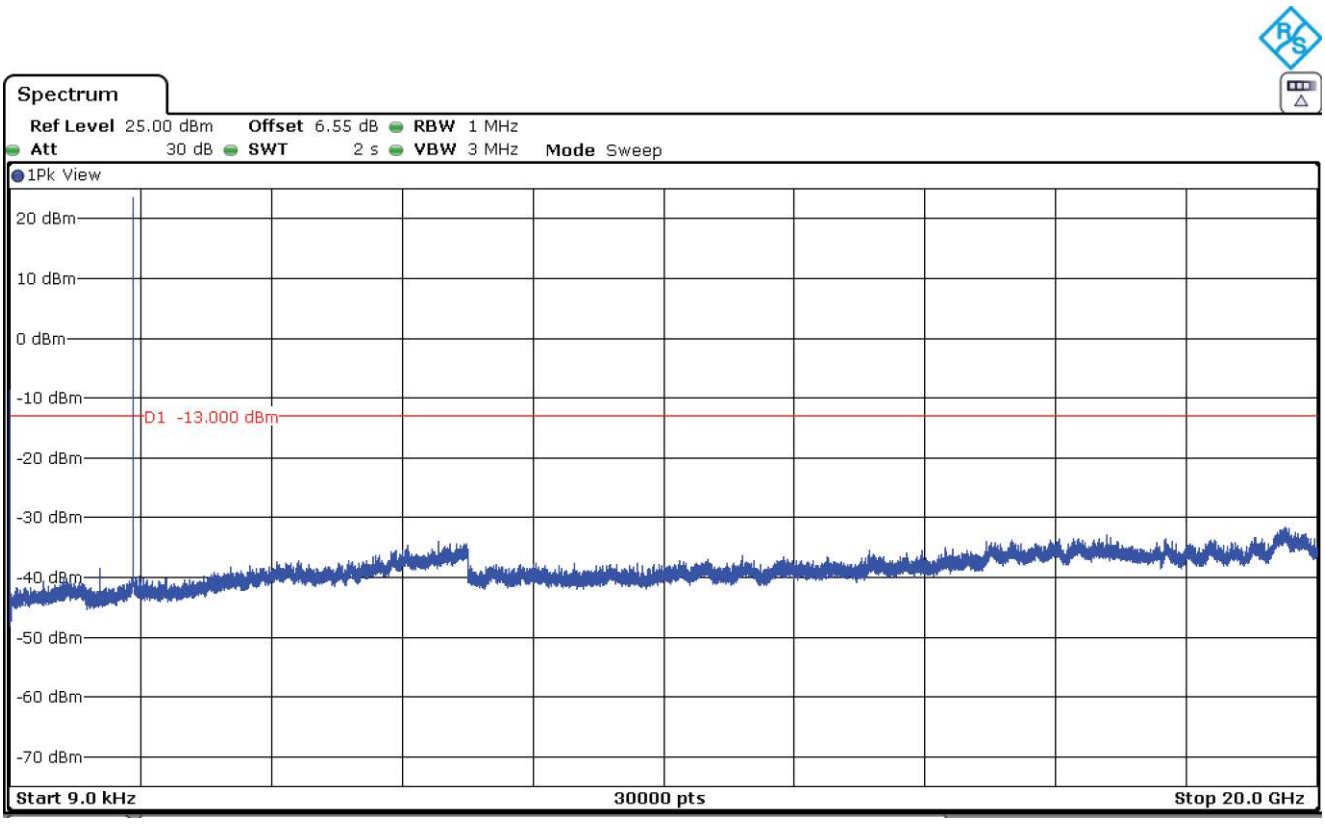
NBIoT BAND 25 (Tone 3.75 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST



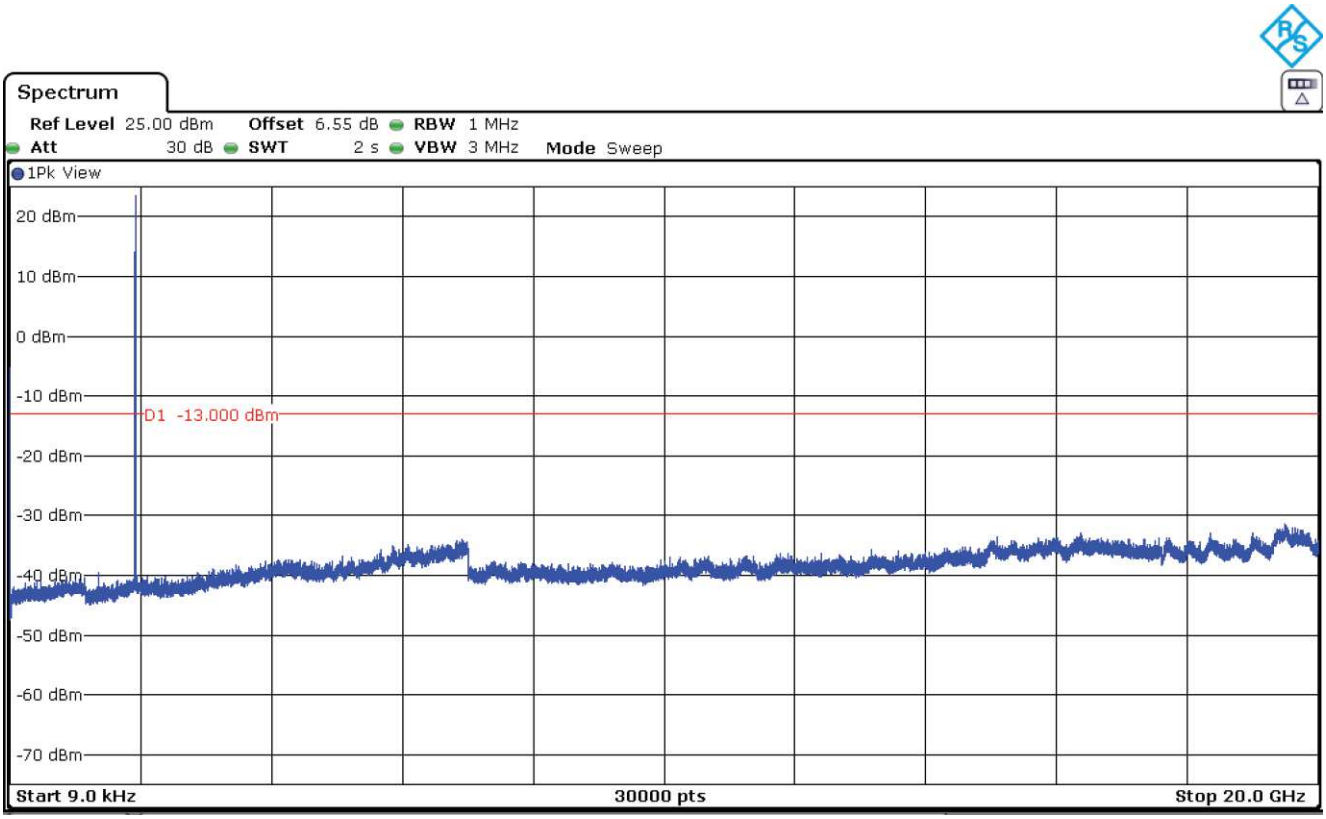

Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE




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

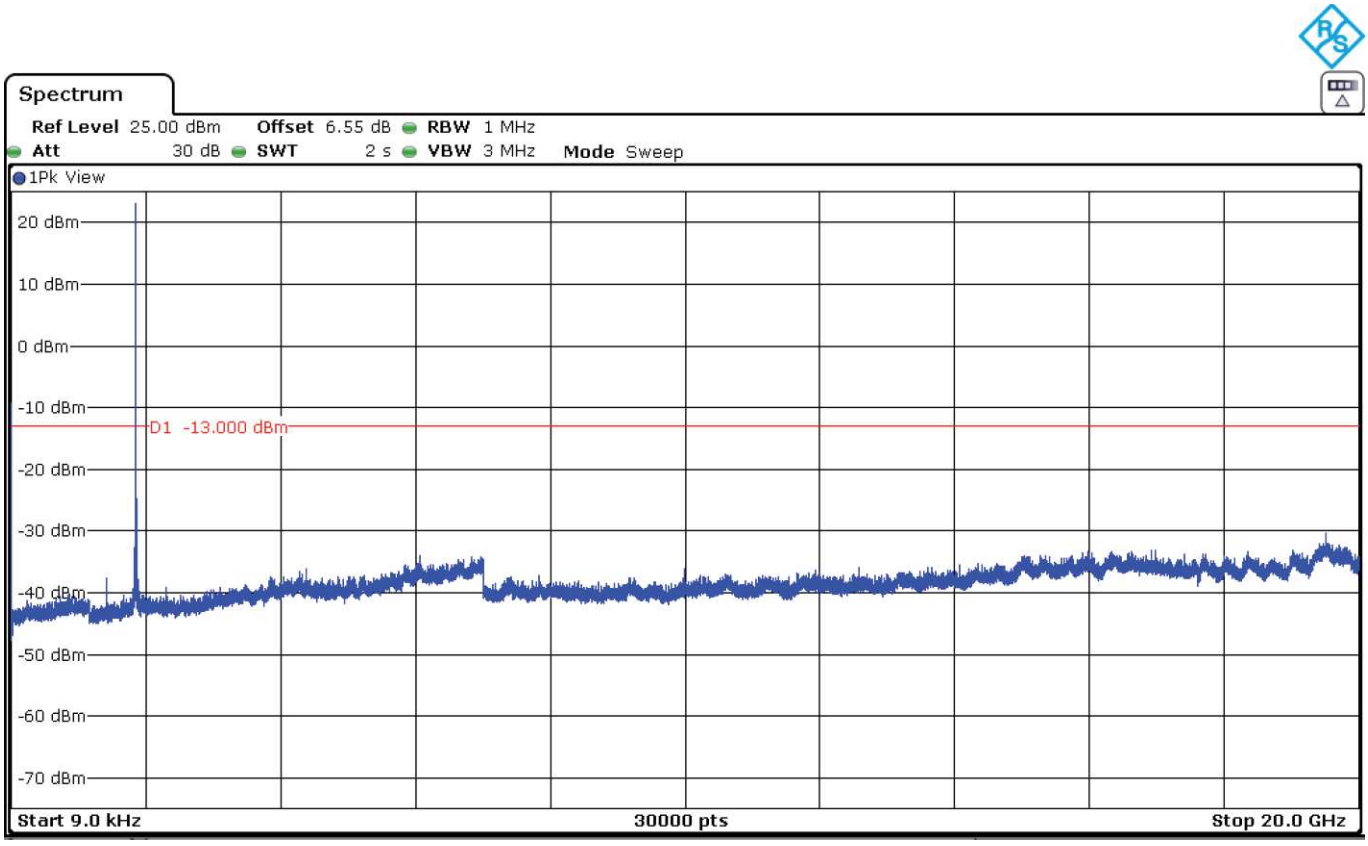
3. CHANNEL: HIGHEST




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

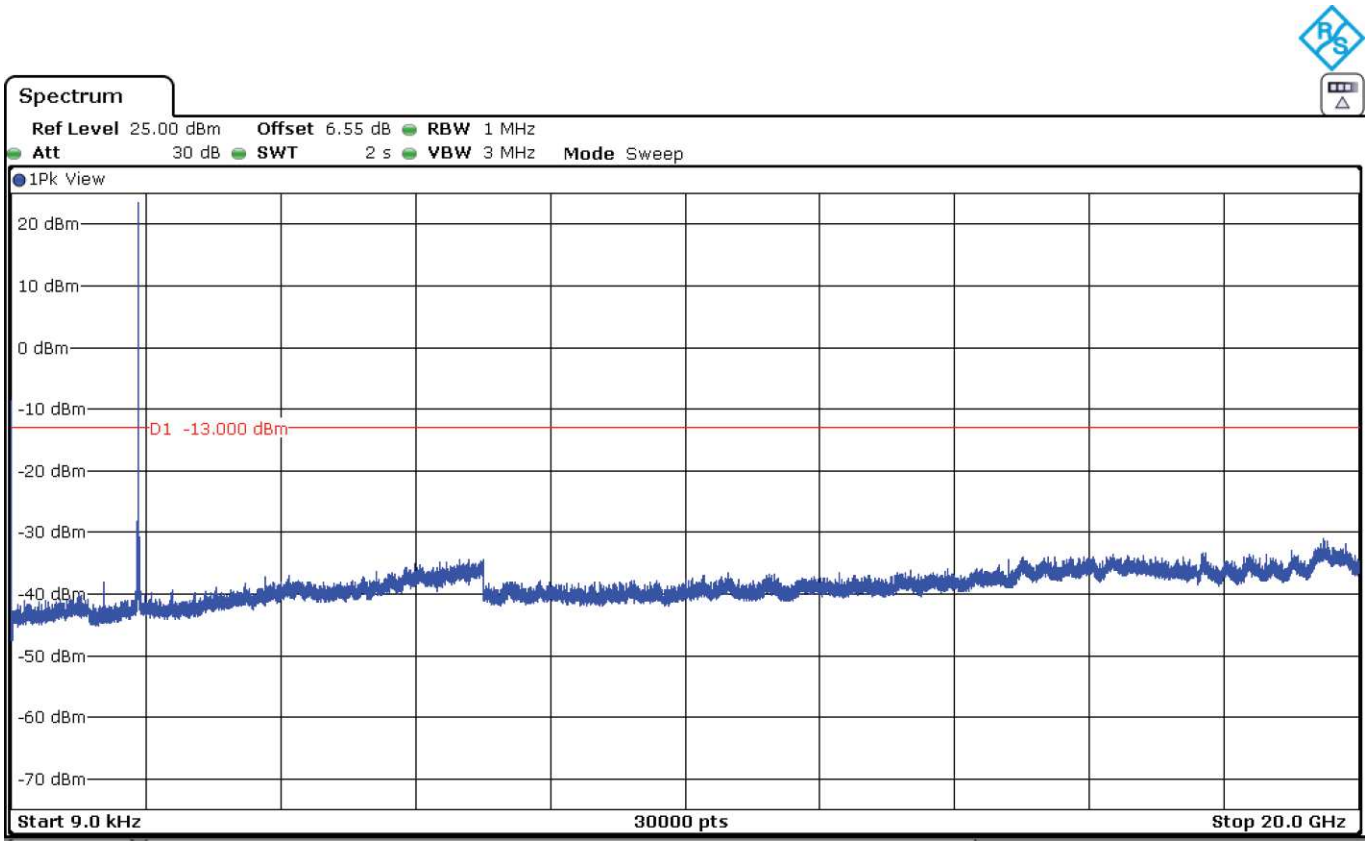
NBIoT BAND 25 (Tone 15 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST



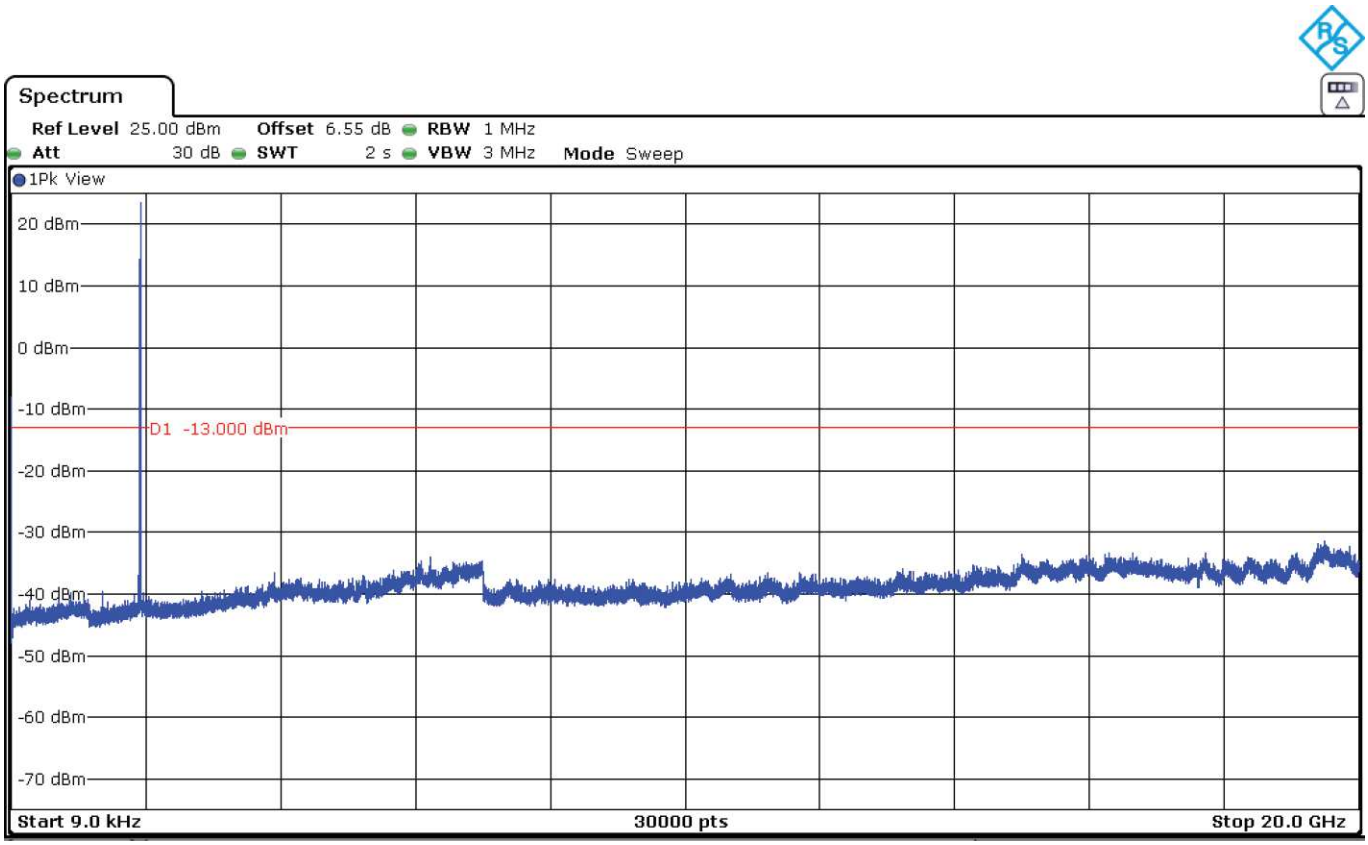

Note: The peak above the limit is the carrier frequency.

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 §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.

As indicated in FCC part 24/RSS-133. in the 1 MHz bands immediately outside and adjacent to the frequency block or band a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed.

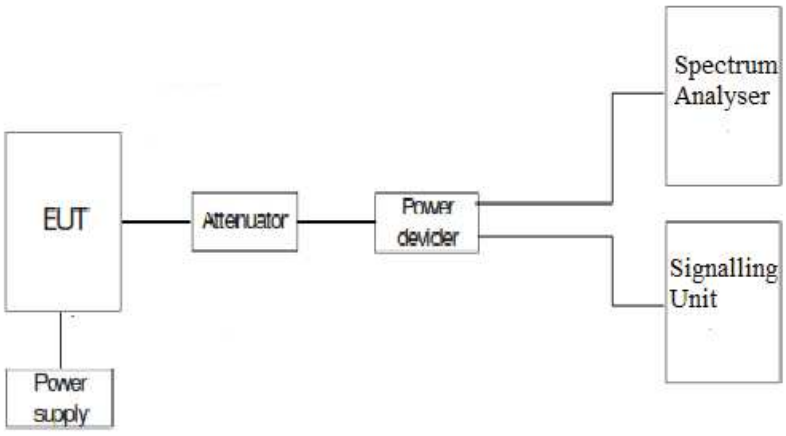
The configuration of modulation which is the worst case for conducted power was used.

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:

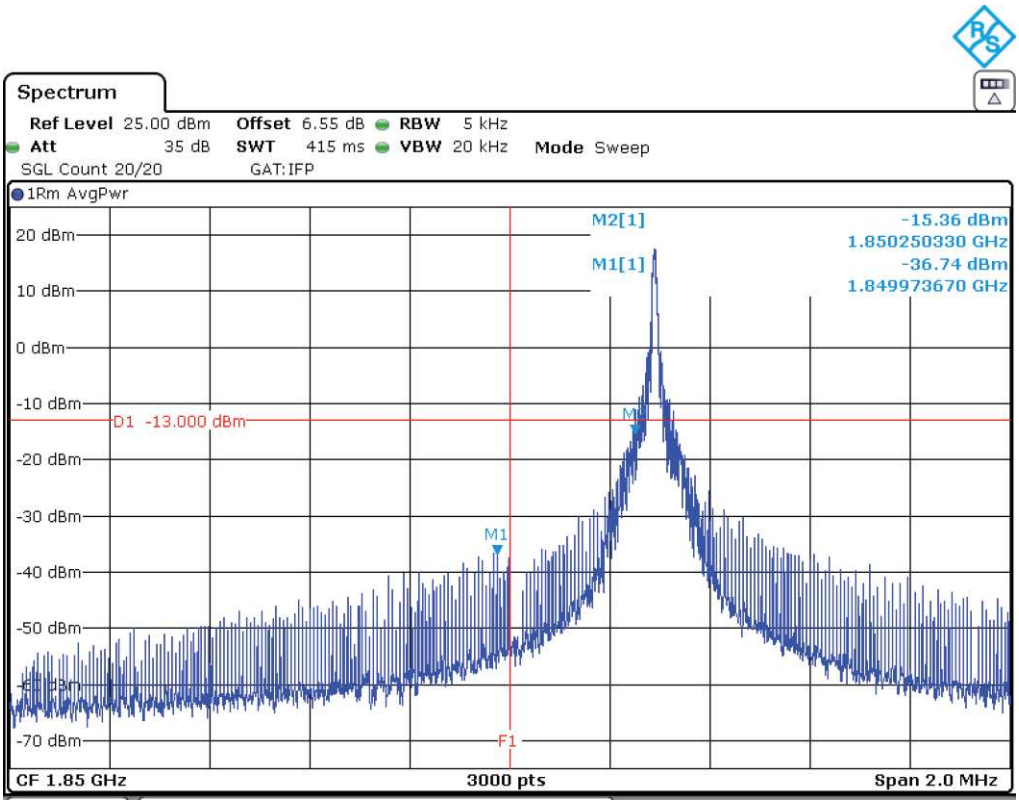
| NBIoT | Tone 3.75 kHz. π/4 - QPSK Offset 0 MCS/TBS=3 | Tone 15kHz. π/2 - BPSK Offset 0 MCS/TBS=0 | 12 Tone 15kHz. π/2 - BPSK Offset 0 MCS/TBS=0 |
|---|---|---|---|
| Maximum measured level at lowest Block Edge at antenna port (dBm) | -36.74 | -22.02 | -23.99 |

| NBIoT | Tone 3.75 kHz. π/4 - QPSK Offset 0 MCS/TBS=3 | Tone 15kHz. π/2 - BPSK Offset 0 MCS/TBS=0 | 12 Tone 15kHz. π/2 - BPSK Offset 0 MCS/TBS=0 |
|---|---|---|---|
| Maximum measured level at highest Block Edge at antenna port (dBm) | -35.21 | -32.21 | -26.53 |

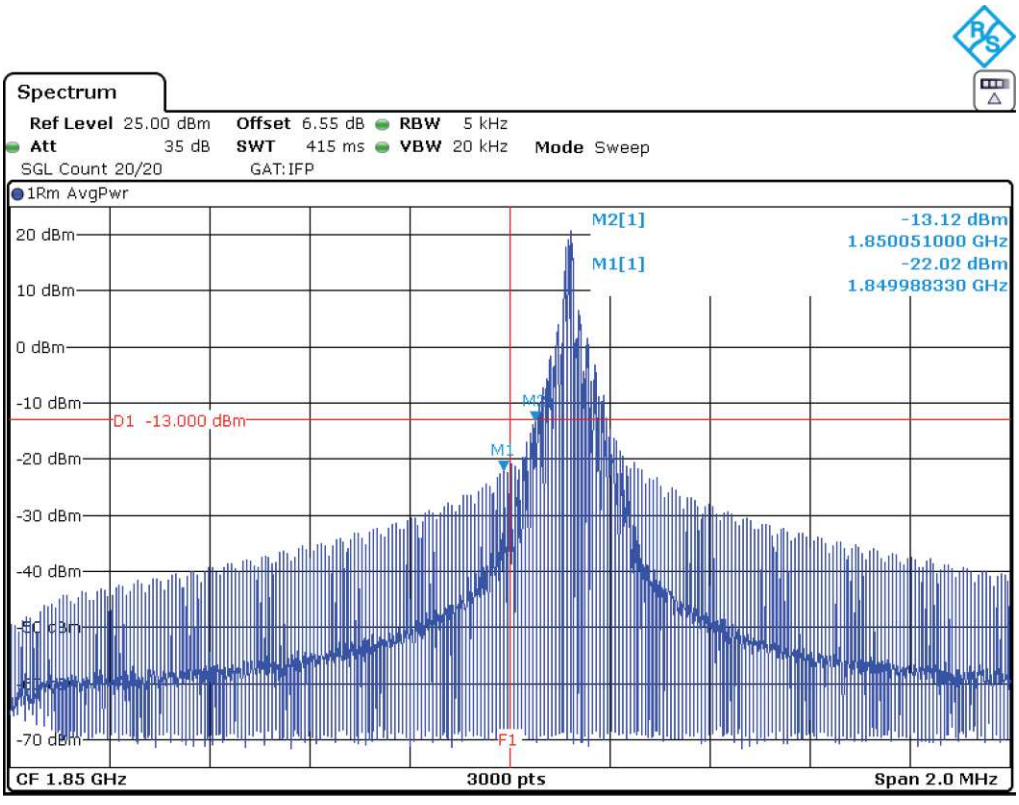
Measurement uncertainty = ±1.57 dB.

NBIoT BAND 25 (Tone 3.75 kHz. π/2 - QPSK Offset 0 MODULATION)

Lowest Channel:

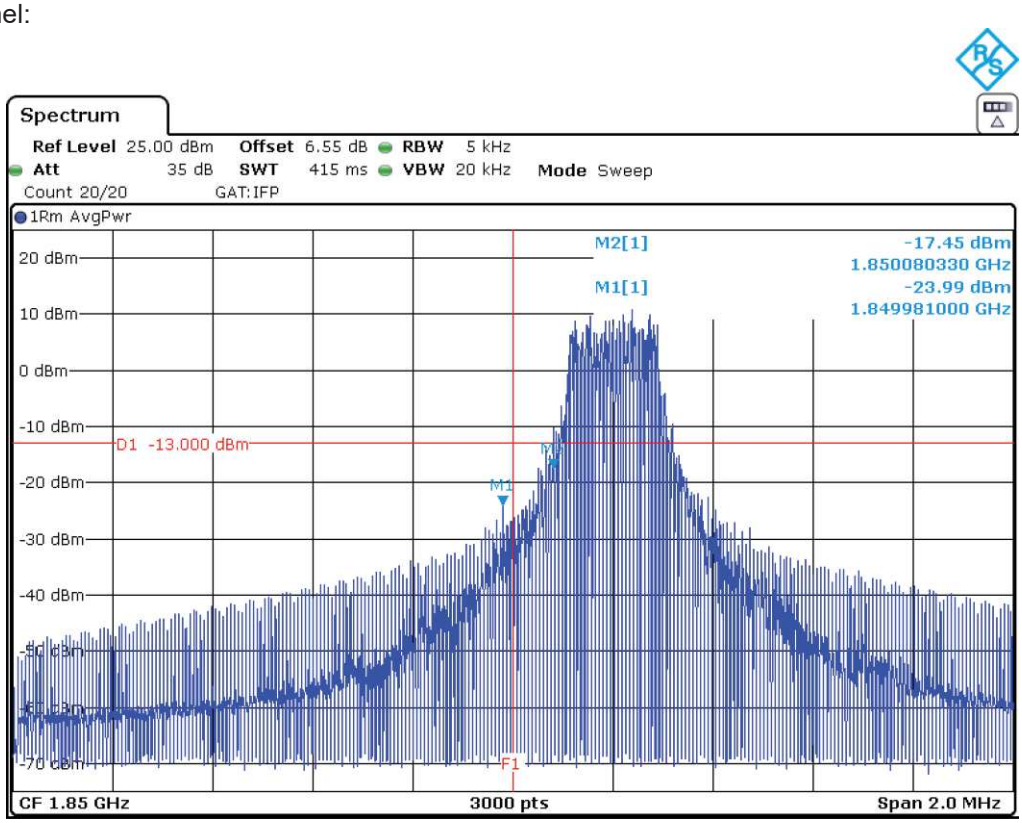



NBIoT BAND 25 (Tone 15 kHz. π/2 - BPSK Offset 0 MODULATION)
Lowest Channel:



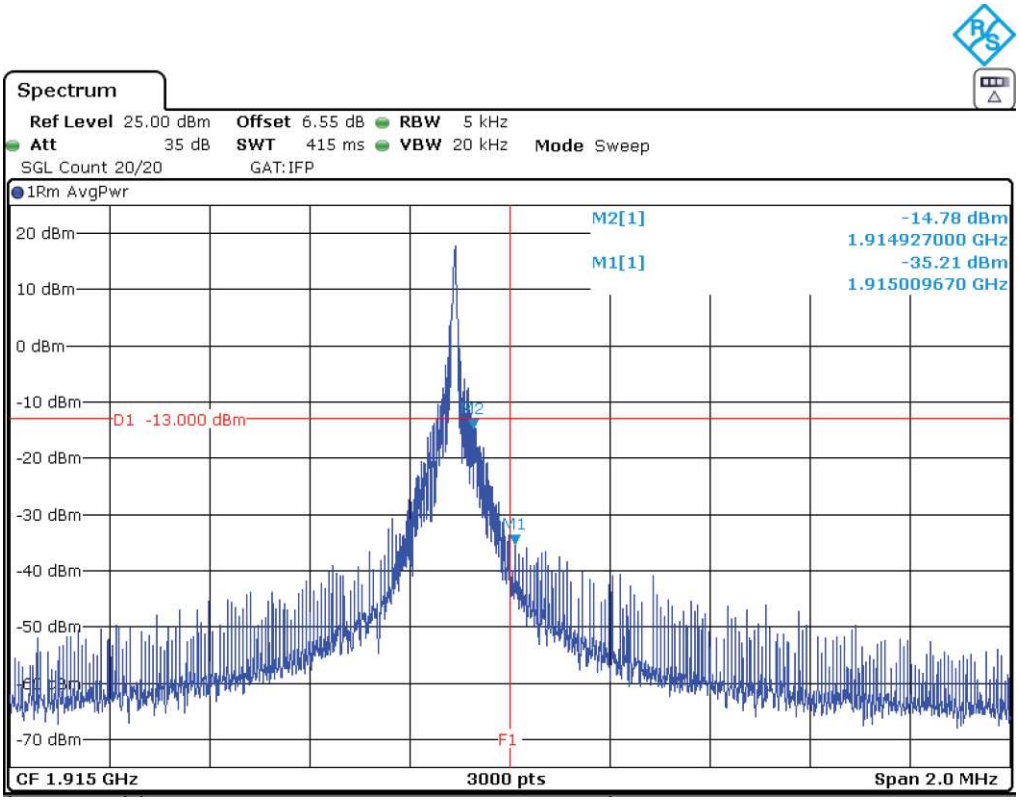
NBIoT BAND 25 (12 Tones 15 kHz. π/4 - QPSK Offset 0 MODULATION)

Lowest Channel:



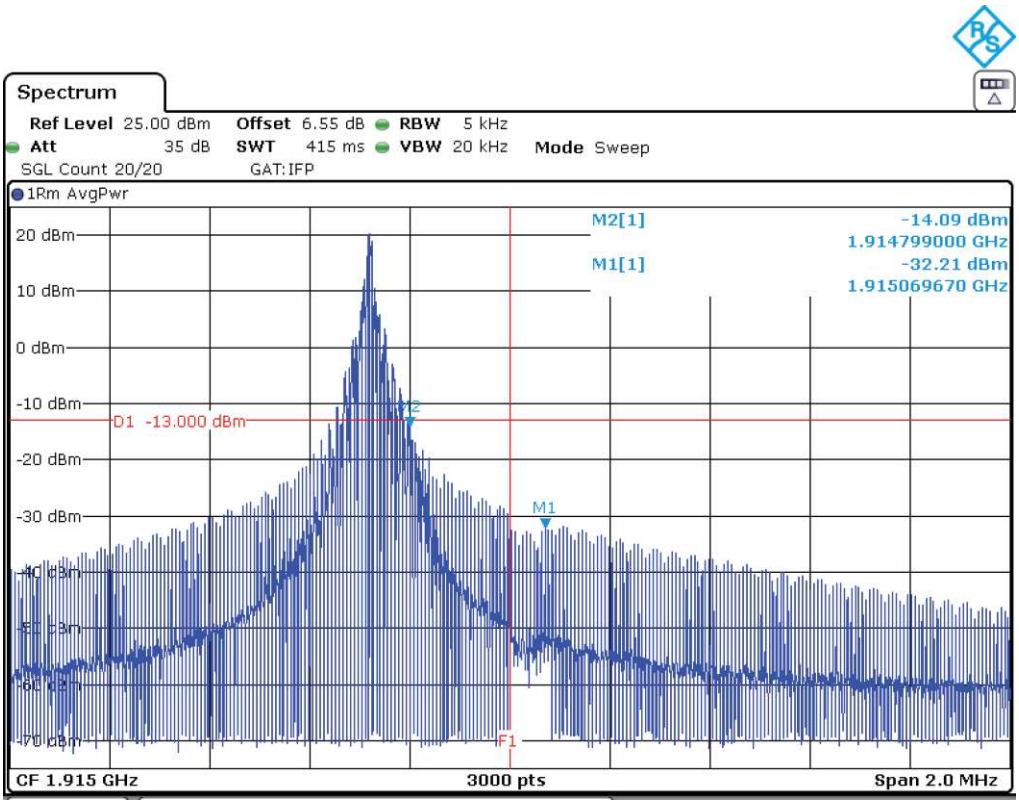

NBIoT BAND 25 (Tone 3.75 kHz. π/4 - QPSK Offset 47 MODULATION)

Highest Channel:



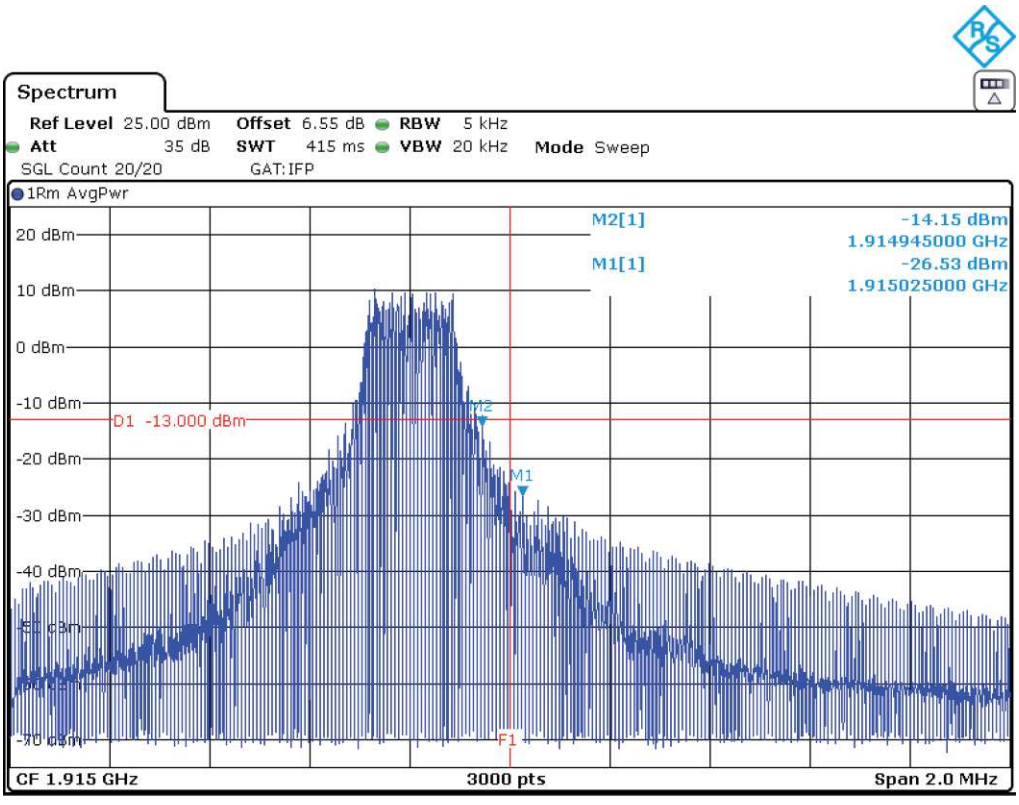
NBIoT BAND 25 (Tone 15 kHz. π/2 - BPSK Offset 11 MODULATION)

Highest Channel:




NBIoT BAND 25 (12 Tones 15 kHz. π/4 - QPSK Offset 0 MODULATION)

Highest Channel:



# 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.

Detected emissions were maximized at each frequency by rotating the EUT and adjusting the measuring antenna height and polarization. The maximum field strength (dBµV/m) is measured and recorded.

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

EIRP (dBm) = E (dBµV/m) + 20log(D) - 104.8; where D is the measurement distance (in the far field region) in m. D = 3 m

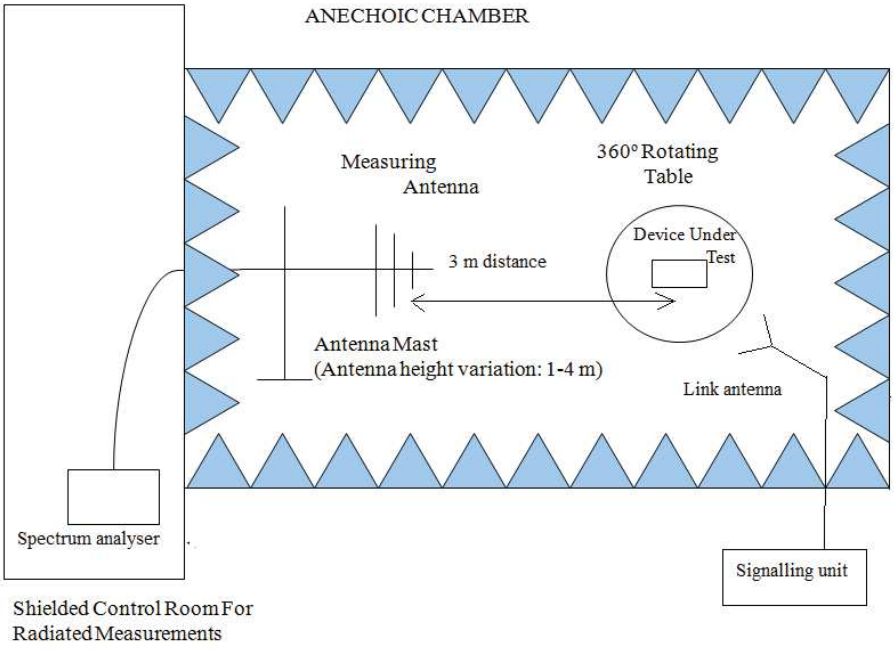
Measurement Limit:

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:

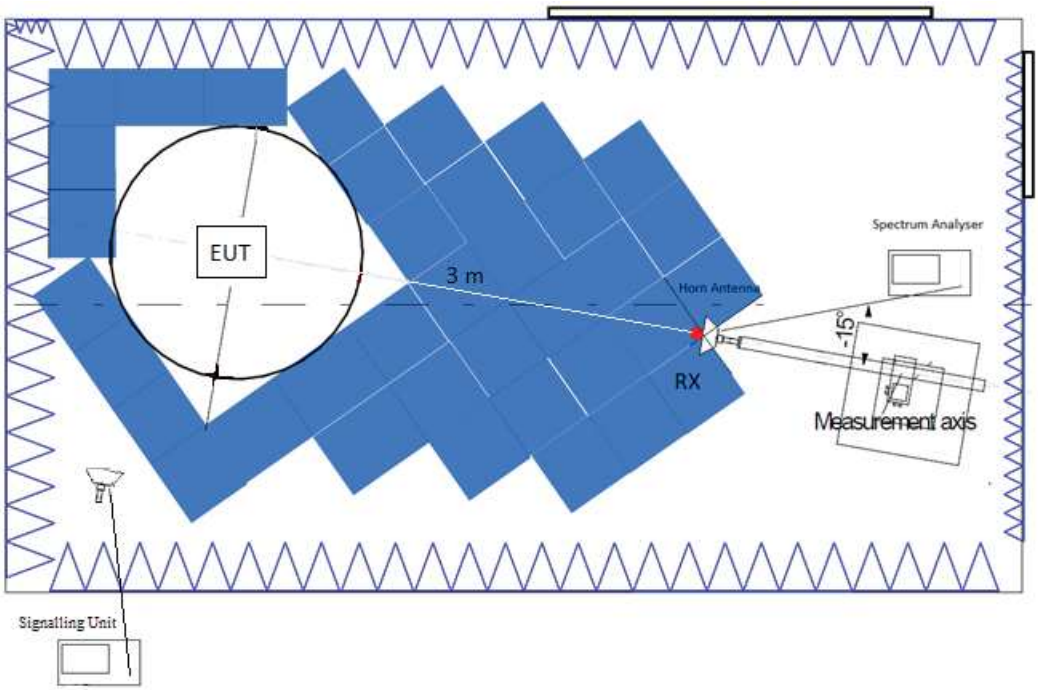
Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = - 13 dBm

## TEST SETUP

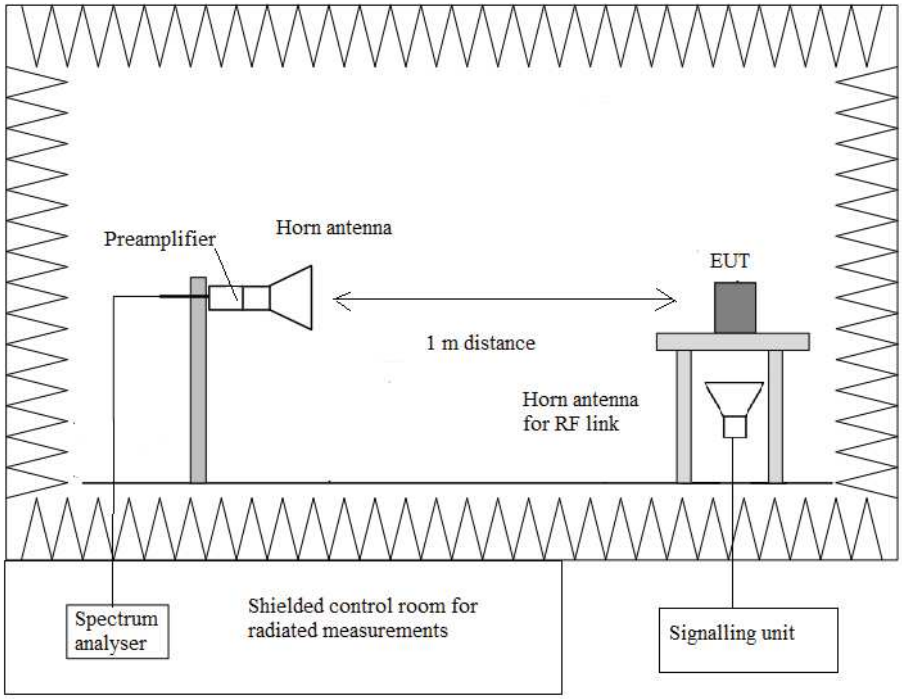
Radiated measurements below 1 GHz.




Radiated measurements between 1 GHz to 18GHz.



Radiated measurements above 18 GHz.



RESULTS

NBIoT. BAND 25.

Preliminary measurements determined that 1 tone of 3.75kHz (π/4 – QPSK) 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.

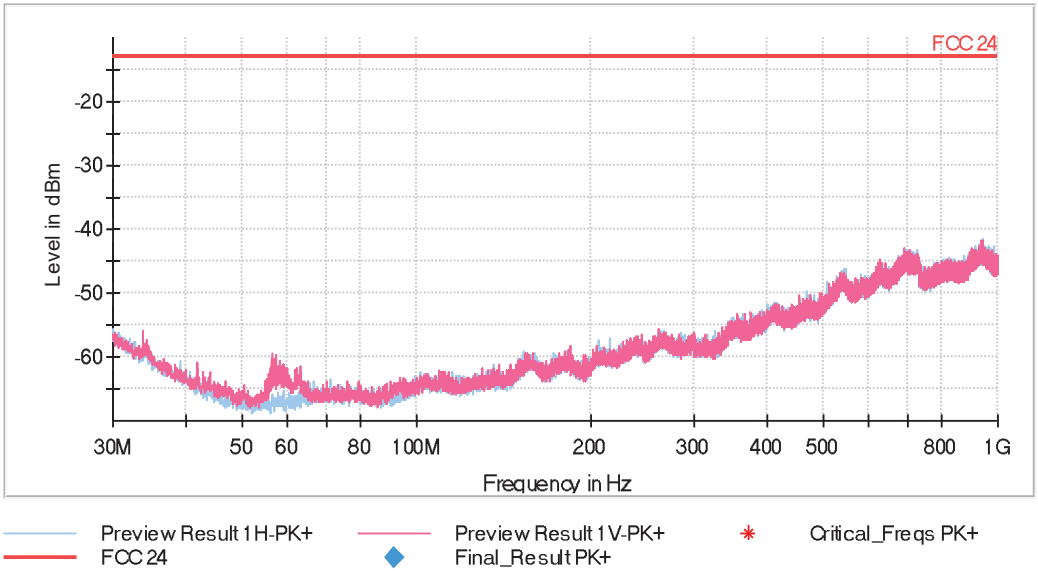
**Frequency range 18 GHz-20 GHz.**
No radiated spurious signals were detected at less than 20 dB respect to the limit.

| | |
|---|---|
| Measurement uncertainty (dB) | <±4.65 for f < 1GHz<br><±3.98 for f ≥ 1 GHz up to 3 GHz<br><±4.98 for f ≥ 3 GHz up to 17 GHz<br><±5.33 for f ≥ 17 GHz up to 20 GHz |

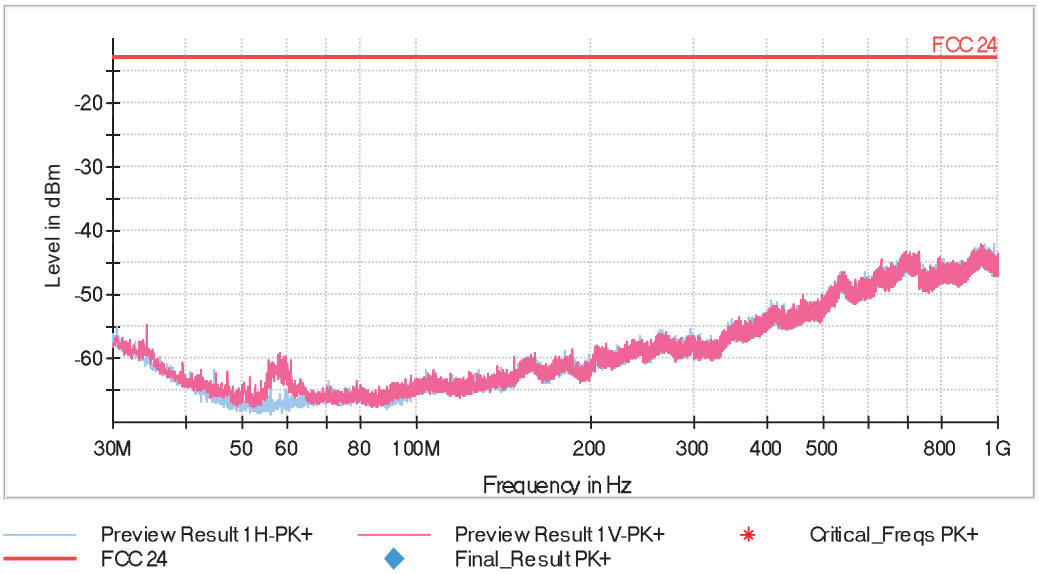
Verdict: PASS

## FREQUENCY RANGE 30 MHz-1000 MHz.

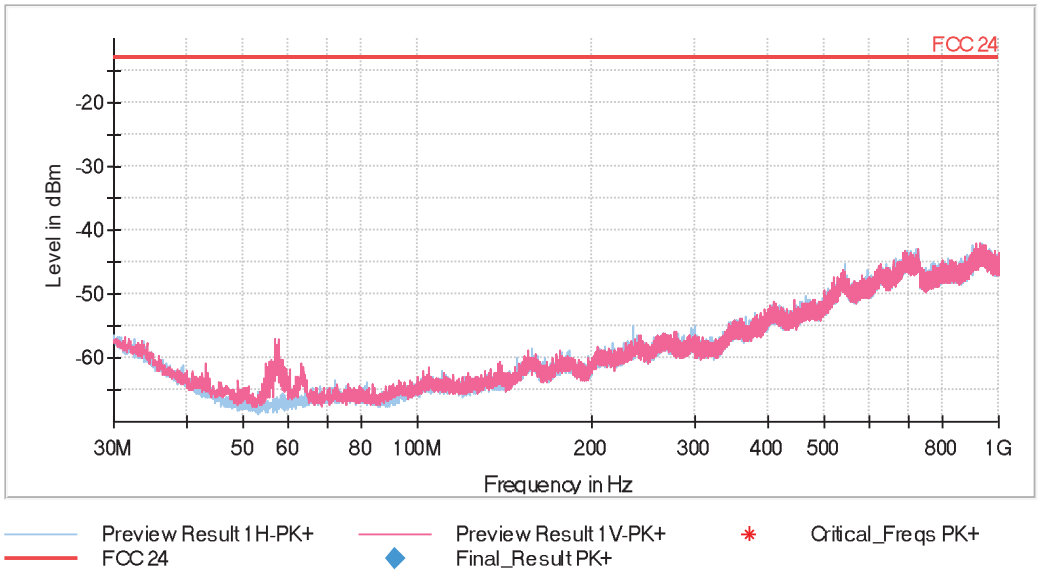
CHANNEL: LOWEST




CHANNEL: MIDDLE

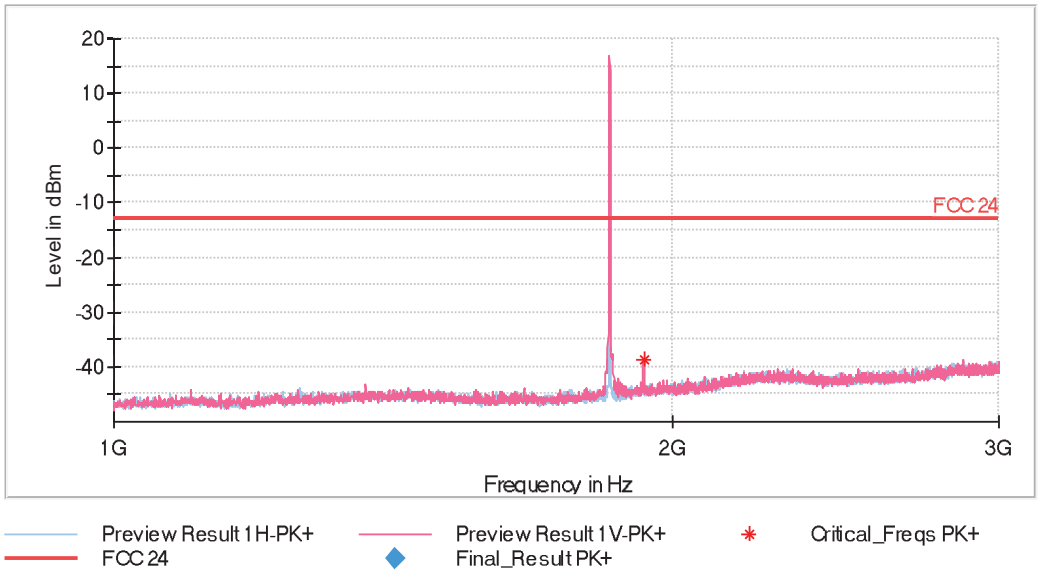


CHANNEL: HIGHEST



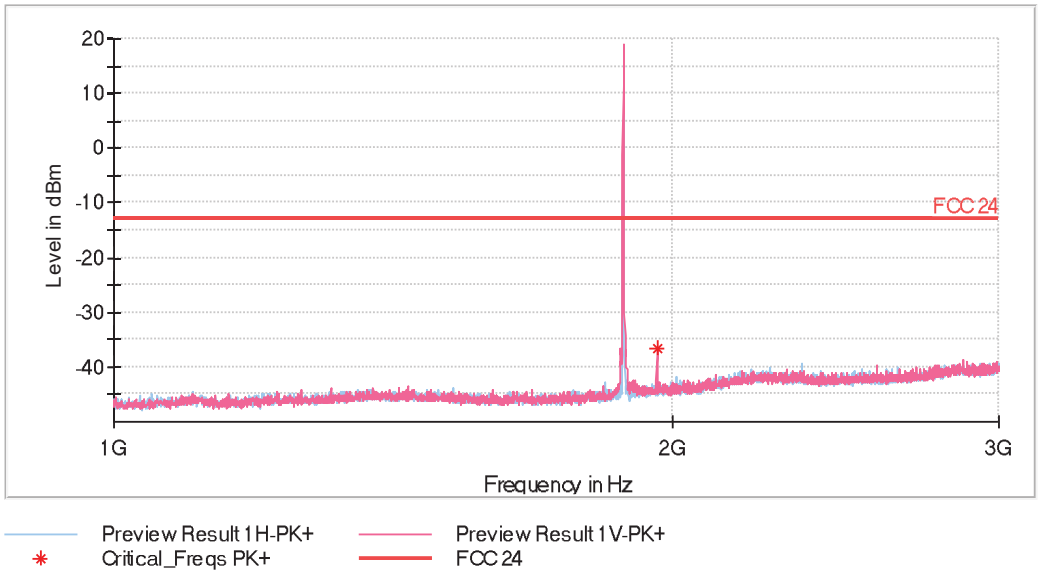
Frequency range 1 GHz to 3 GHz

CHANNEL: LOWEST



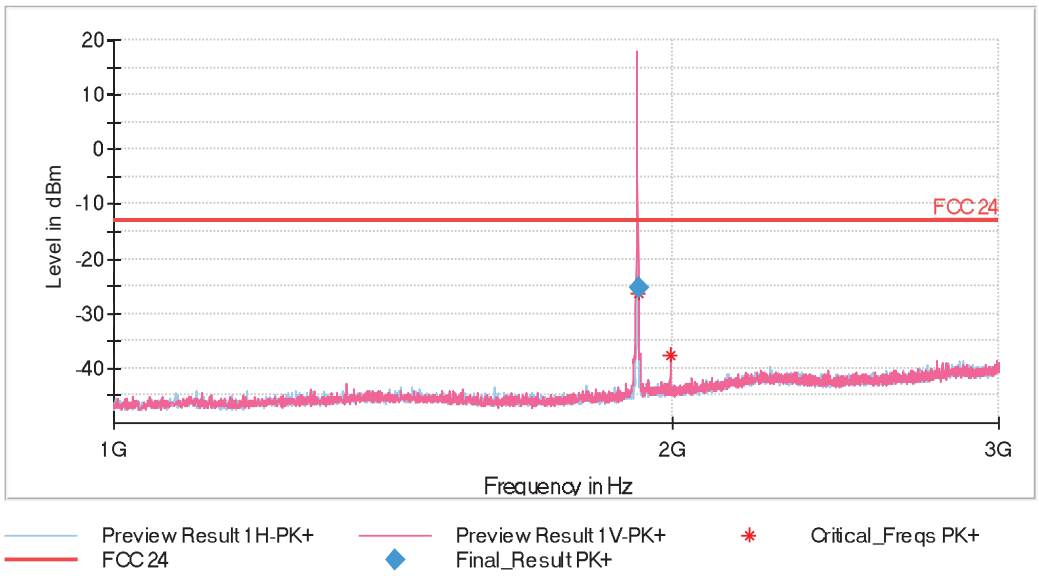

Note: The peak above the limit is the carrier frequency. The peak at 1930MHz corresponds to the downlink signal

CHANNEL: MIDDLE




Note: The peak above the limit is the carrier frequency. The peak at 1962.5MHz corresponds to the downlink signal

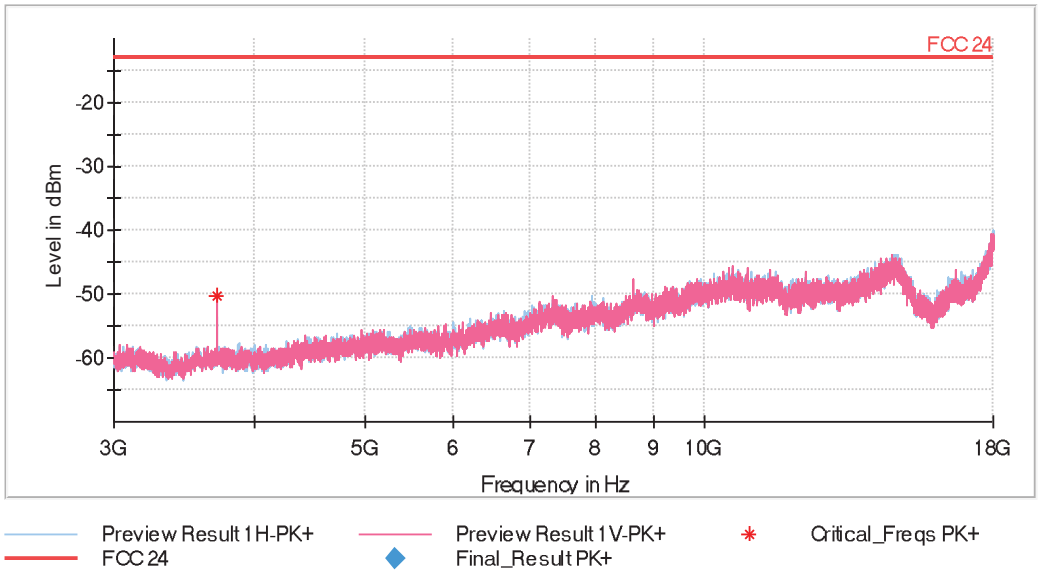
CHANNEL: HIGHEST



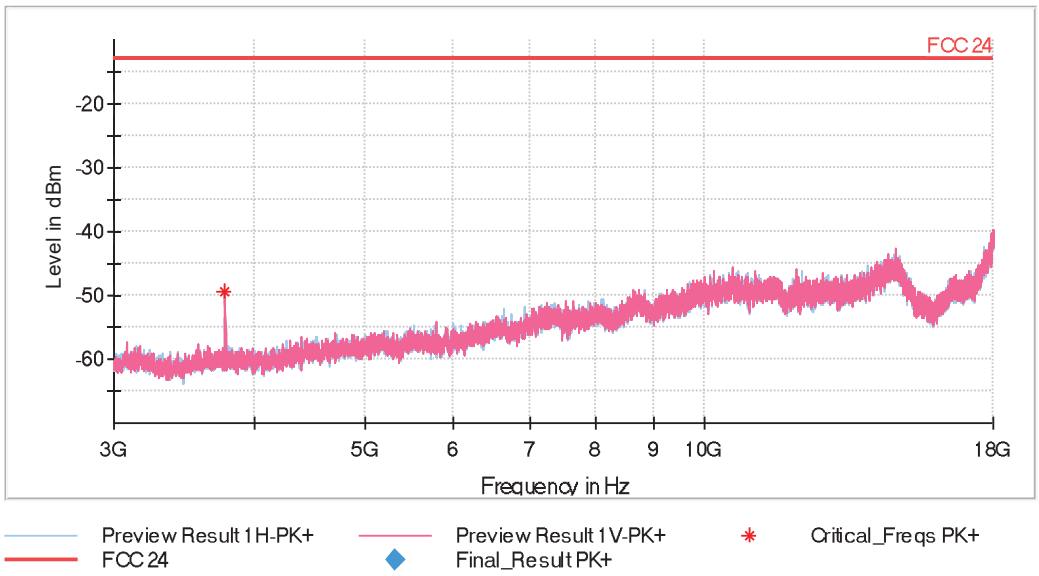

Note: The peak above the limit is the carrier frequency. The peak at 1995MHz corresponds to the downlink signal

Frequency range 3 GHz to 18 GHz

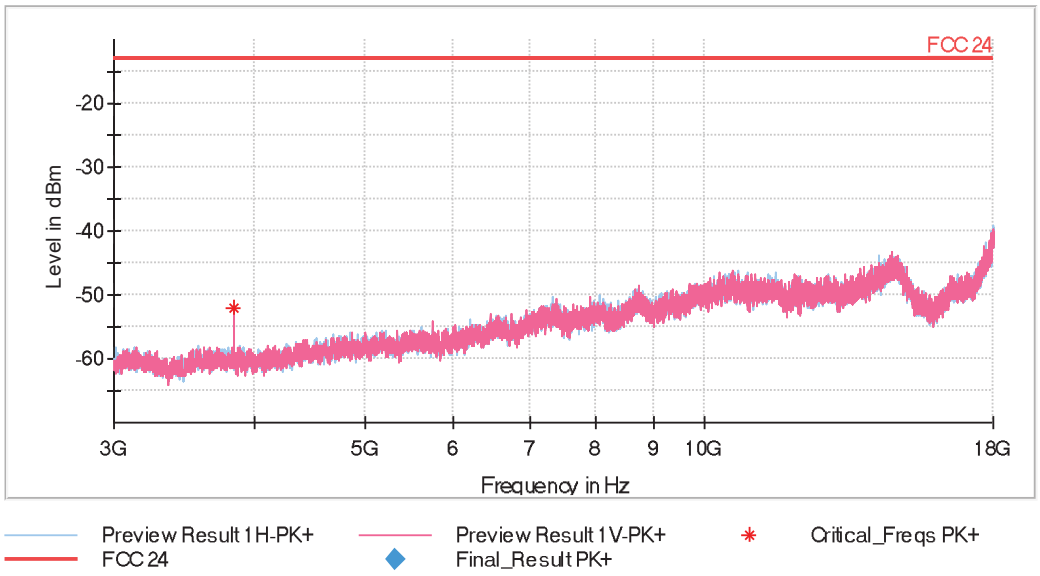
CHANNEL: LOWEST



CHANNEL: MIDDLE

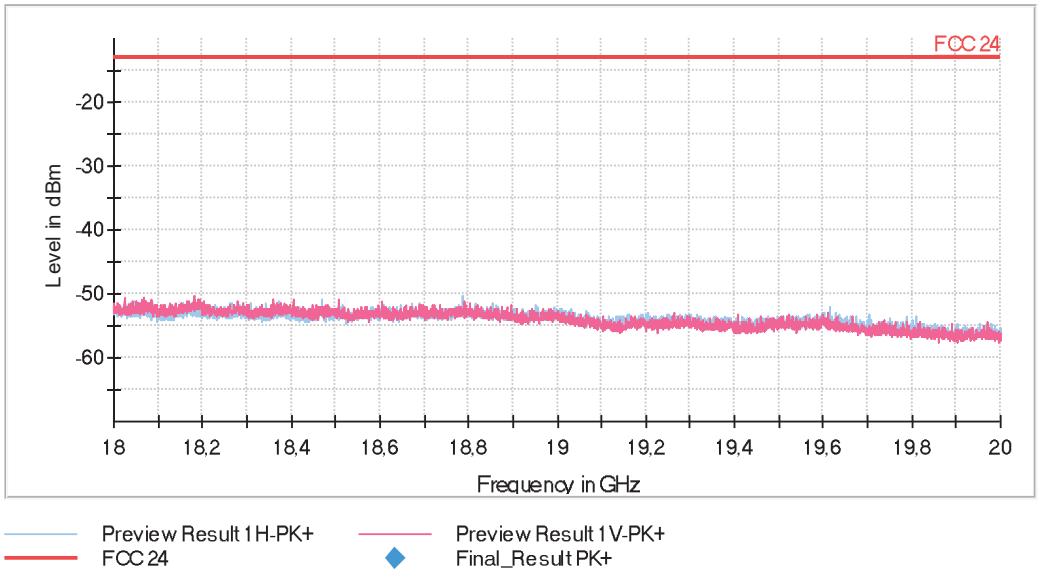



CHANNEL: HIGHEST

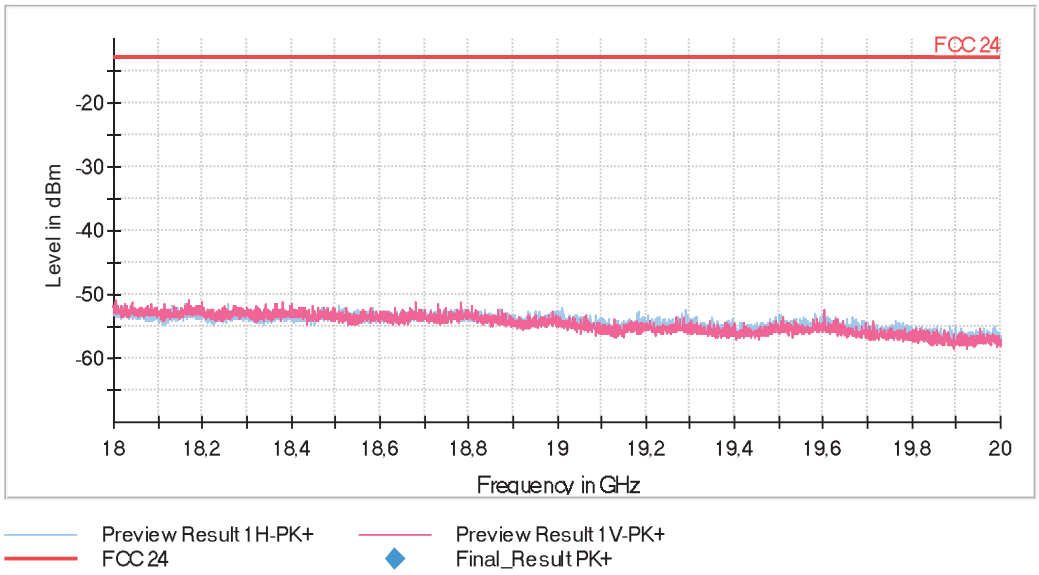


## Frequency range 18 GHz to 20 GHz

CHANNEL: LOWEST




CHANNEL: MIDDLE



CHANNEL: HIGHEST