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

ISED CABid: ES1909

Test report No:
NIE: 66585RRF.001A3

Test report

REFERENCE STANDARD:
USA FCC Part 22 & Part 24 & Part 27 & Part 90
CANADA IC RSS-130 & RSS-132 & RSS-133 & RSS-139

(*) Identification of item tested	Data radio module
(*) Trademark	Telit
(*) Model and /or type reference tested	NE310L2-W1
Other identification of the product	HW version: 1.0 SW version: M0P.000001 IMEI TAC: 35188185 FCC ID: RI7NE310L2W1 IC: 5131A-NE310L2W1
(*) Features	LTE FDD Bands: 1, 2, 3, 4, 5, 8, 12, 13, 18, 19, 20, 25, 26, 28, 66, 85
Applicant	Telit Communications S.p.A. Via Stazione di Prosecco 5/B 34010, Sgonico – Trieste, ITALY
Test method requested. standard	USA FCC Part 22 10-1-19 Edition. USA FCC Part 24 10-1-19 Edition. USA FCC Part 27 10-1-19 Edition. USA FCC Part 90 10-1-19 Edition. CANADA RSS-130 Issue 2, Feb. 2019. CANADA RSS-132 Issue 3, Jan. 2013. CANADA RSS-133 Issue 6, Amendment 1 Jan. 2018. CANADA RSS-139 Issue 3, Jul. 2015. ANSI C63.26-2015. KDB 971168 D01 Power Meas License Digital Systems v03r01, April. 2018
Approved by (name / position & signature)	Rafael Lopez EMC Consumer & RF Lab. Manager 2021.10.01 13:24:59 +02'00'
Date of issue	2021-10-01
Report template No	FDT08_23 (*) "Data provided by the client"

Index

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 S.A.U. is an FCC-recognized accredited testing laboratory with the appropriate scope of accreditation that covers the performed tests in this report.

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

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

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

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

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

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

General conditions

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

Data provided by the client

The following data has been provided by the client:

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

2. The sample consists of a LTE Cat NB2 Radio Module.

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

Usage of samples

Samples undergoing test have been selected by: the client.

Sample S/01 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	HW version	Date of reception
66585B/048	Data radio module	NE310L2-W1	3518818599966252	1.0	2021/05/11

Auxiliary elements used with the Sample S/01:

Control Nº	Description	Model	Serial Nº	Date of reception
66585B/006	Cradle – EVK	---	---	2021/02/24
66585B/024	LTE Antenna	T-AT305-BU	---	2021/02/24

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

- The following tests indicated in Appendixes B and C:
- RF Output power in NBIoT Band 13 and 66.
- Occupied Bandwidth, Frequency stability, spurious emission at antenna terminal at Block Band Edge and radiated emissions in NBIoT Band 13.
- Spurious emission at antenna terminal at Block Band Edge in NBIoT Band 12.
- Spurious emission at antenna terminal at Block Band Edge in NBIoT Band 85.
- Radiated emissions in NBIoT Band 66.
- Occupied Bandwidth Frequency stability in NBIoT Band 66.

Sample S/02 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	HW version	Date of reception
66585B/019	Data radio module	NE310L2-W1	351881859998500	0.0	2020/04/14

Auxiliary elements used with the Sample S/02:

Control Nº	Description	Model	Serial Nº	Date of reception
66585B/020	Cradle – EVK	---	---	2021/02/24
66585B/024	LTE Antenna	T-AT305-BU	---	2021/02/24

1. Sample S/02 has undergone the following test(s):

The rest of tests indicated in Appendixes A, B and C.

Test sample description

<table>
<tr><td rowspan="2">Ports…… :</td><td rowspan="2">Port name and description</td><td colspan="4">Cable</td></tr>
<tr><td>Specified max length [m]</td><td>Attached during test</td><td>Shielded</td><td>Coupled to patient(3)</td></tr>
<tr><td></td><td>---</td><td></td><td>[ ]</td><td>[ ]</td><td>[ ]</td></tr>
<tr><td>Supplementary information to the ports…… :</td><td colspan="5">---</td></tr>
<tr><td rowspan="4">Rated power supply .....:</td><td colspan="2" rowspan="2">Voltage and Frequency</td><td colspan="4">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>[X]</td><td colspan="5">DC: 3.2– 4.2VDC (typ 3.8 VDC)</td></tr>
<tr><td>Rated Power .....:</td><td colspan="6">23 dBm</td></tr>
<tr><td>Clock frequencies.....:</td><td colspan="6">Clock 26MHz, XTAL 32.768kHz</td></tr>
<tr><td>Other parameters .....:</td><td colspan="6">-30°C to + 70°C</td></tr>
<tr><td>Software version .....:</td><td colspan="6">M0P.000001</td></tr>
<tr><td>Hardware version .....:</td><td colspan="6">1.0</td></tr>
<tr><td>Dimensions in cm (W x H x D) ....:</td><td colspan="6">13.1 x 14.3 mm</td></tr>
<tr><td rowspan="5">Mounting position .....:</td><td>[ ]</td><td colspan="5">Table top equipment</td></tr>
<tr><td>[ ]</td><td colspan="5">Wall/Ceiling mounted equipment</td></tr>
<tr><td>[ ]</td><td colspan="5">Floor standing equipment</td></tr>
<tr><td>[ ]</td><td colspan="5">Hand-held equipment</td></tr>
<tr><td>[X]</td><td colspan="5">Other: solder down on host equipment</td></tr>
<tr><td rowspan="3">Modules/parts.....:</td><td colspan="3">Module/parts of test item</td><td>Type</td><td colspan="2">Manufacturer</td></tr>
<tr><td colspan="3">None, the device is module itself</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3"></td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="3">Accessories (not part of the test item) .....:</td><td colspan="3">Description</td><td>Type</td><td colspan="2">Manufacturer</td></tr>
<tr><td colspan="3">Antenna only for testing purposed</td><td>T-AT305</td><td colspan="2">ATEL-CAB</td></tr>
<tr><td colspan="3"></td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="2">Documents as provided by the applicant.....:</td><td colspan="3">Description</td><td>File name</td><td colspan="2">Issue date</td></tr>
<tr><td colspan="3">---</td><td></td><td colspan="2"></td></tr>
</table>

(3) Only for Medical Equipment

Identification of the client

Telit Communications S.p.A.
Via Stazione di Prosecco 5/B
34010, Sgonico – Trieste, ITALY

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2020-03-19
Date (finish)	2020-06-15

Document history

Report number	Date	Description
66585RRF.001	2021-06-23	First reléase
66585RRF.001A1	2021-07-14	Second release: - Added the identifier CABid to the report. - Modification due to typos. - This modification test report cancels and replaces the test report 66585RRF.001.
66585RRF.001A2	2021-07-22	Third release: - Removed the NBIoT band 17. - This modification test report cancels and replaces the test report 66585RRF.001A1.
66585RRF.001A3	2021-10-01	Fourth release: -Modification due to typo version of the standard RSS 130. - This modification test report cancels and replaces the test report 66585RRF.001A2.

Environmental conditions

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

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar

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

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar

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

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar

Remarks and comments

The tests have been performed by the technical personnel: Cristina Calle, Nicolás Salguero, Javier Nadales, Verónica García and Alfonso Gutierrez.

Used instrumentation:

Conducted Measurements

		Last Cal. date	Cal. due date
1.	DC Power Supply 40V/40A Rohde & Schwarz NGPE40	N/A	N/A
2.	Digital Multimeter FLUKE 179	2020/10	2021/10
3.	Wideband Radio Communication Tester ROHDE AND SCHWARZ CMW500	2021/02	2022/02
4.	Wideband Radio Communication Tester ROHDE AND SCHWARZ CMW500	2021/01	2022/02
5.	Spectrum Analyzer ROHDE AND SCHWARZ FSW50	2020/07	2022/07
6.	Spectrum Analyzer ROHDE AND SCHWARZ FSV40	2020/03	2022/03

Radiated Measurements:

		Last Calibration	Due Calibration
1.	Semianechoic Absorber Lined Chamber ETS FACT3 200STP	N/A	N/A
2.	Shielded Room ETS LINDGREN S101	N/A	N/A
3.	EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2020/12	2022/12
4.	Preamplifier G>40dB 10MHz-6GHz, BONN ELEKTRONIK, BLNA 0160-01N	2021/03	2022/03
5.	Biconical/Log Antenna 30 MHz - 6 GHz ETS LINDGREN 3142E	2020/04	2023/04
6.	Spectrum Analyzer ROHDE AND SCHWARZ FSW50	2020/07	2022/07
7.	Horn Antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2019/11	2022/11
8.	RF Preamplifier, 40 dB ,1-18 GHz BONN ELEKTRONIK BLMA 0118-1M	2021/06	2022/06
9.	DC Power Supply 40V/40A Rohde & Schwarz NGPE40	N/A	N/A
10.	Digital Multimeter FLUKE 179	2020/10	2021/10
11.	Wideband Radio Communication Tester ROHDE AND SCHWARZ CMW500	2021/02	2022/02
12.	Wideband Radio Communication Tester ROHDE AND SCHWARZ CMW500	2021/01	2022/02
13.	RF pre-amplifier, G>30dB, 18-40 GHz BONN ELEKTRONIK BLMA 1840-3G	2019/11	2021/11
14.	Broadband Horn antenna 18-40 GHz SCHWARZBECK BBHA 9170	2018/07	2021/07

Testing verdicts

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

Summary

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

FCC PART 24/IC RSS-133 PARAGRAPH 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: None.		

FCC PART 27 / RSS-139 / RSS-130 PARAGRAPH Requirement – Test case	Verdict	Remark
Clause 27.50 / RSS-139 Clause 6.5. / RSS-130 Clause 4.6.: RF output power	P	
Clause 2.1047 / RSS-139 Clause 6.2. / RSS-130 Clause 4.2.: Modulation characteristics	P	
Clause 27.54 / RSS-139 Clause 6.4. / RSS-130 Clause 4.5.: Frequency stability	P	
Clause 2.1049: Occupied Bandwidth	P	
Clause 27.53 / RSS-139 Clause 6.6. / RSS-130 Clause 4.7.: Spurious emissions at antenna terminals	P	
Clause 27.53 / RSS-139 Clause 6.6. / RSS-130 Clause 4.7.: Radiated emissions	P	
Supplementary information and remarks: (1) None.		

FCC PART 90 PARAGRAPH Requirement – Test case	Verdict	Remark
Clause 90.635 (b): RF output power	P	
Clause 2.1047: Modulation characteristics	P	
Clause 90.213 Frequency stability	P	
Clause 2.1049: Occupied Bandwidth	P	
Clause 90.691 Spurious emissions at antenna terminals (Emission mask requirements for EA-based systems)	P	
Clause 90.691: Radiated emissions	P	
Supplementary information and remarks: None.		

Appendix A: Test results for FCC Part 22 & 90 / RSS-132

INDEX

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:

814-824MHz Band:

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 26)

Channel (Frequency. MHz)		
Lowest	Middle	Highest
26692 (814.2)	26740 (819)	26788 (823.8)

Cross-rule channel (824MHz):

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 26)

Channel (Frequency. MHz)
26790 (824)

824-849MHz Band:

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 5)

Channel (Frequency. MHz)		
Lowest	Middle	Highest
20402 (824.2)	20525 (836.5)	20648 (848.8)

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 26)

Channel (Frequency. MHz)		
Lowest	Middle	Highest
26792 (824.2)	26915 (836.5)	27038 (848.8)

NOTE: Band 26 is completely included in band 5, so the channels of band 5 were tested to give conformity to the assigned block.

RF Output Power

SPECIFICATION

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

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

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

FCC §90.635. The maximum output power of the transmitter for mobile stations is 100 watts (20 dBw).

The peak-to-average power ratio (PAPR) 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).

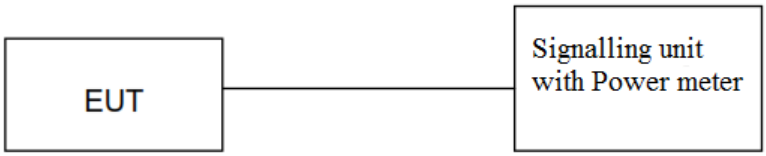
The maximum effective radiated power e.r.p. is calculated from the maximum equivalent isotropically radiated power (e.i.r.p.) by subtracting 2.15 dB:

E.R.P. = E.I.R.P. – 2.15 dB

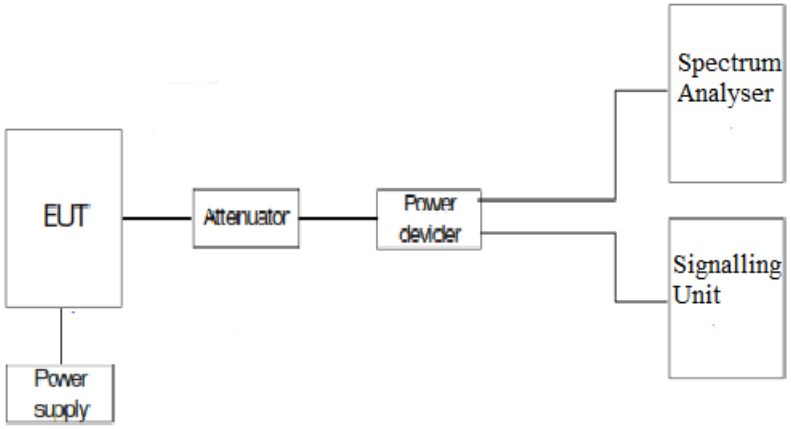
The peak-to-average power ratio (PAPR) is measured using an attenuator. power splitter and spectrum analyser with a Complementary Cumulative Distribution Function implemented.
The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT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

TEST SETUP

Conducted average power.



Peak-to-average power ratio (PAPR)



RESULTS

814-824 MHz Band:

Ch	Freq. (MHz)	Modulation	BW (kHz)	Num. tone	Offset Tone	Average Power (dBm)	PAPR (dB)
26692	814.2	π/2 - BPSK	3.75	1	0	22.64	(*)
				1	47	22.65	(*)
			15	1	0	22.48	(*)
				1	11	22.48	(*)
		π/4 - QPSK	3.75	1	0	22.7	(*)
				1	47	22.66	(*)
			15	1	0	22.32	(*)
				1	11	22.38	(*)
				3	0	21.83	4.37
				3	6	21.76	4.47
				6	0	21.3	5.99
				6	6	21.31	5.95
				12	0	20.32	6.76
26740	819	π/2 - BPSK	3.75	1	0	22.62	(*)
				1	47	22.6	(*)
			15	1	0	22.49	(*)
				1	11	22.28	(*)
		π/4 - QPSK	3.75	1	0	22.72	(*)
				1	47	22.7	(*)
			15	1	0	22.38	(*)
				1	11	21.69	(*)
				3	0	21.8	4.41
				3	6	21.73	4.42
				6	0	21.27	5.99
				6	6	21.25	6.06
				12	0	20.27	6.57
26788	823.8	π/2 - BPSK	3.75	1	0	22.68	(*)
				1	47	22.69	(*)
			15	1	0	22.22	(*)
				1	11	21.91	(*)
		π/4 - QPSK	3.75	1	0	22.75	(*)
				1	47	22.74	(*)
			15	1	0	22.33	(*)
				1	11	22.21	(*)
				3	0	21.79	4.41
				3	6	21.73	4.44
				6	0	21.22	6.01
				6	6	21.23	6.09
				12	0	20.27	6.6

(*): 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.

Cross-rule channel (824MHz):

Ch	Freq. (MHz)	Modulation	BW (kHz)	Num. tone	Offset Tone	Average Power (dBm)	PAPR (dB)
26790	824	π/2 - BPSK	3.75	1	0	22.69	(*)
				1	47	22.68	(*)
			15	1	0	22.1	(*)
				1	11	22.22	(*)
		π/4 - QPSK	3.75	1	0	22.77	(*)
				1	47	22.76	(*)
			15	1	0	22.54	(*)
				1	11	22.49	(*)
				3	0	21.9	4.4
				3	6	21.84	4.45
				6	0	21.31	6.01
				6	6	21.33	5.96
				12	0	20.37	6.88

(*): 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.

824-849MHz Band:

Ch	Freq. (MHz)	Modulation	BW (kHz)	Num. tone	Offset Tone	Average Power (dBm)	PAPR (dB)
20402	824.2	π/2 - BPSK	3.75	1	0	22.9	(*)
				1	47	22.83	(*)
			15	1	0	22.95	(*)
				1	11	22.87	(*)
		π/4 - QPSK	3.75	1	0	23.09	(*)
				1	47	22.86	(*)
			15	1	0	22.78	(*)
				1	11	22.7	(*)
				3	0	21.99	4.41
				3	6	22.42	4.31
				6	0	21.42	6.01
				6	6	21.41	5.95
				12	0	20.39	6.47
20525	836.5	π/2 - BPSK	3.75	1	0	23.11	(*)
				1	47	23.09	(*)
			15	1	0	22.81	(*)
				1	11	22.74	(*)
		π/4 - QPSK	3.75	1	0	23.18	(*)
				1	47	23.16	(*)
			15	1	0	22.64	(*)
				1	11	22.56	(*)
				3	0	21.91	4.42
				3	6	22.34	4.31
				6	0	21.29	5.99
				6	6	21.32	6.01
				12	0	20.36	6.71
20648	848.8	π/2 - BPSK	3.75	1	0	23.17	(*)
				1	47	23.14	(*)
			15	1	0	22.94	(*)
				1	11	22.87	(*)
		π/4 - QPSK	3.75	1	0	23.18	(*)
				1	47	23.17	(*)
			15	1	0	22.76	(*)
				1	11	22.72	(*)
				3	0	21.98	4.36
				3	6	22.45	4.31
				6	0	21.4	5.96
				6	6	21.42	5.9
				12	0	20.36	6.58

(*): 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.

814-824 MHz Band:

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	22.70	+2.15	24.85	22.70
Middle	22.72	+2.15	24.87	22.72
Highest	22.75	+2.15	24.90	22.75
Measurement uncertainty (dB)	<±0.941			

Cross-rule channel (824MHz):

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)
26790 (824)	22.77	+2.15	25.02	22.77
Measurement uncertainty (dB)	<±0.941			

824-849MHz Band:

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	23.09	+2.15	25.24	23.09
Middle	23.18	+2.15	25.33	23.18
Highest	23.18	+2.15	25.33	23.18
Measurement uncertainty (dB)	<±0.941			

Verdict: PASS

PEAK-TO-AVERAGE POWER RATIO (PAPR).

814-824 MHz Band

NBIoT BAND 26.

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	20.33 dBm
Peak	27.17 dBm
Crest	6.84 dB
10 %	2.61 dB
1 %	5.11 dB
.1 %	6.52 dB
.01 %	6.76 dB

Channel Middle:

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

	Trace 1
Mean	20.31 dBm
Peak	27.18 dBm
Crest	6.87 dB
10 %	2.64 dB
1 %	5.16 dB
.1 %	6.57 dB
.01 %	6.78 dB

Channel High:

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

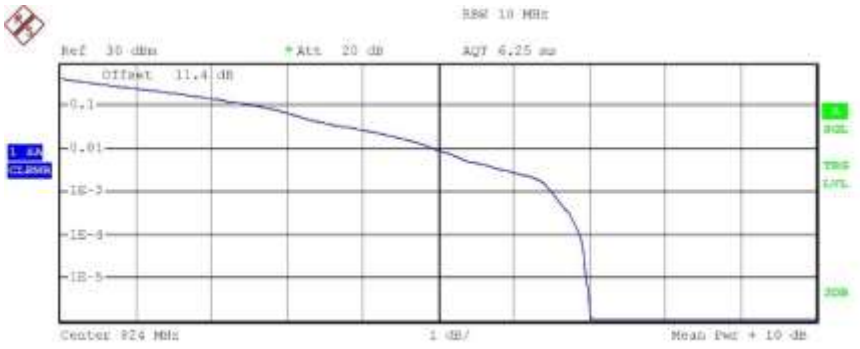
	Trace 1
Mean	20.25 dBm
Peak	27.19 dBm
Crest	6.94 dB
10 %	2.64 dB
1 %	5.16 dB
.1 %	6.60 dB
.01 %	6.88 dB

824 MHz Band

NBIoT BAND 26.

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 824MHz:



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

	Trace 1
Mean	20.24 dBm
Peak	27.26 dBm
Crest	7.02 dB
10 %	2.63 dB
1 %	4.97 dB
.1 %	6.51 dB
.01 %	6.88 dB

824-849 MHz Band

NBIoT BAND 5.

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
MOF samples: 100000, Usable BW: 11.2MHz

	Trace 1
Mean	20.34 dBm
Peak	27.19 dBm
Crest	6.85 dB
10 %	2.61 dB
1 %	5.21 dB
.1 %	6.47 dB
.01 %	6.76 dB

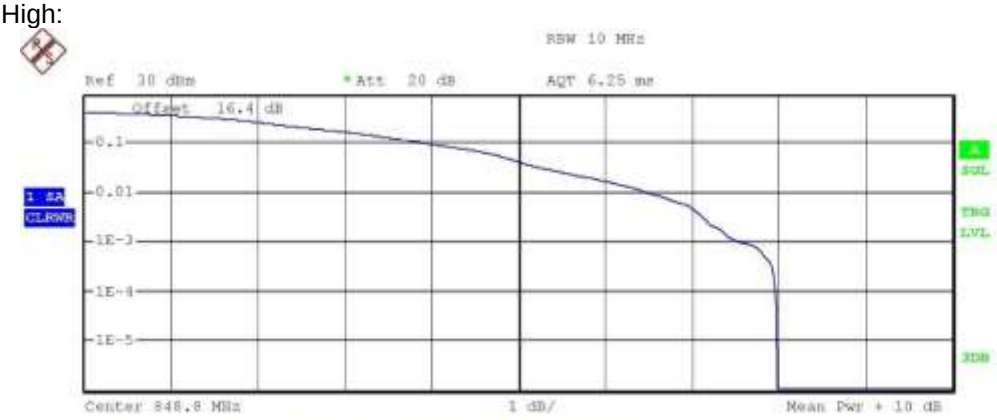
Channel Middle:

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

	Trace 1
Mean	20.24 dBm
Peak	27.28 dBm
Crest	7.04 dB
10 %	2.61 dB
1 %	5.22 dB
.1 %	6.71 dB
.01 %	6.92 dB

Date: 12.APR.2021 07:18:45

Channel High:



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

	Trace 1
Mean	19.60 dBm
Peak	27.58 dBm
Crest	7.98 dB
10 %	4.01 dB
1 %	6.52 dB
.1 %	6.58 dB
.01 %	7.98 dB

Frequency Stability

SPECIFICATION:

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

RSS-132. Clause 5.3. The carrier frequency shall not depart from the reference frequency in excess of ±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.

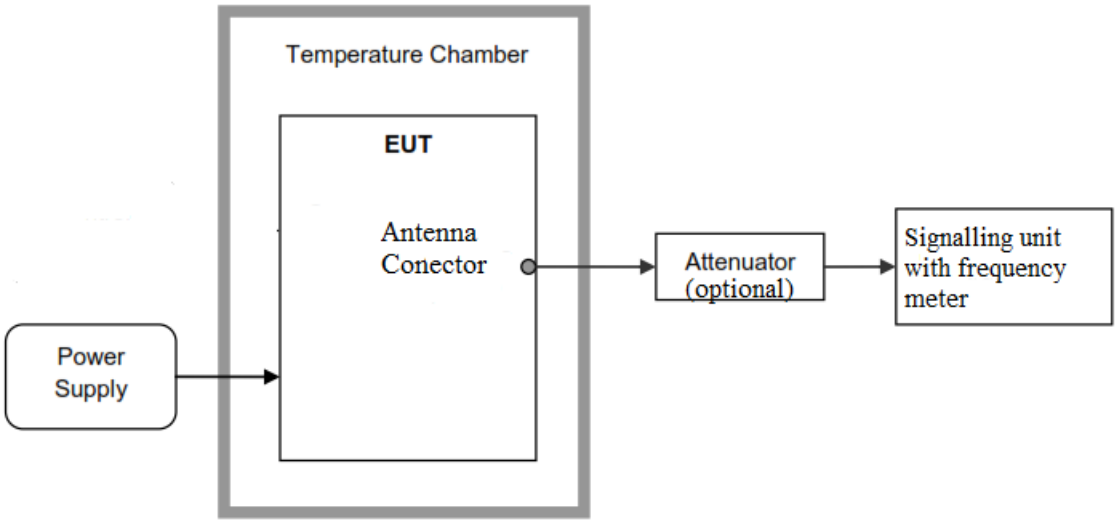
The EUT was set in “Radio Resource Control (RRC) mode” in the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case LTE mode for conducted power was used for the test.

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.

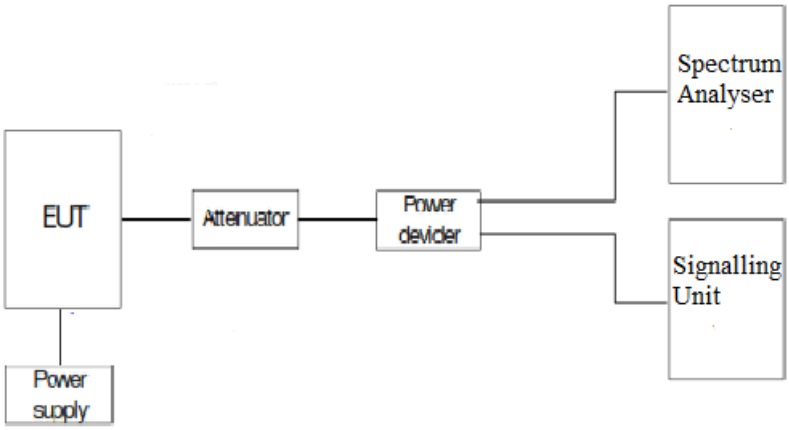
The reference point measurements were made at the RF output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

TEST SETUP:

1. Frequency Tolerance:



2. Reference Frequency Points fL and fH:



RESULTS:

Frequency stability over temperature variations.

NBIoT Band 26. π/4 - QPSK modulation. 1 tone 3.75 kHz. Channel: 819 MHz.

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+50	-11.73	-0.014322344
+40	0.92	0.001123321
+30	5.04	0.006153846
+20	-2.29	-0.002796093
+10	12.69	0.015494505
0	-1.04	-0.001269841
-10	8.15	0.00995116
-20	1.43	0.001746032
-30	4.49	0.005482295

Measurement uncertainty (Hz)	<±100

NBIoT Band 5. π/4 - QPSK modulation. 1 tone 3.75 kHz. Channel: 836.5 MHz.

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+50	-12.02	-0.014369396
+40	-0.79	-0.000944411
+30	-3.72	-0.004447101
+20	4.85	0.005797968
+10	-10.6	-0.012671847
0	4.22	0.00504483
-10	-1.46	-0.001745368
-20	7.08	0.008463837
-30	-2.35	-0.002809325

Measurement uncertainty (Hz)	<±102

Frequency stability over voltage variations.

NBIoT Band 26

Battery Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	4.2	-9.42	-0.011501832
Vmin	3.2	4.86	0.005934066

NBIoT Band 5

Battery Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	4.2	4.19	0.005008966
Vmin	3.2	-11.73	-0.014022714

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

NBIoT Band 26:

Not Applicable.

NBIoT Band 5

*f*L (MHz)	824.0570
fH (MHz)	848.9183

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

NBIoT Band 26:

Not Applicable.

NBIoT Band 5

*f*L (MHz)	824.056987
fH (MHz)	848.918337

Verdict: PASS

Modulation Characteristics

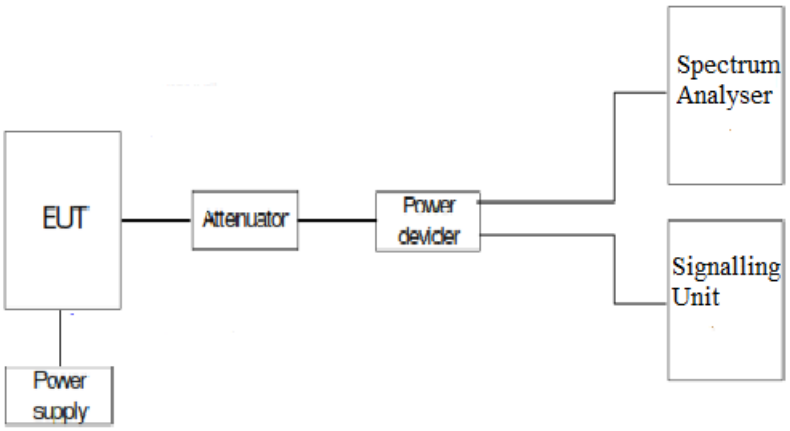
SPECIFICATION
FCC §2.1047.

RSS-132. Clause 5.2: 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.

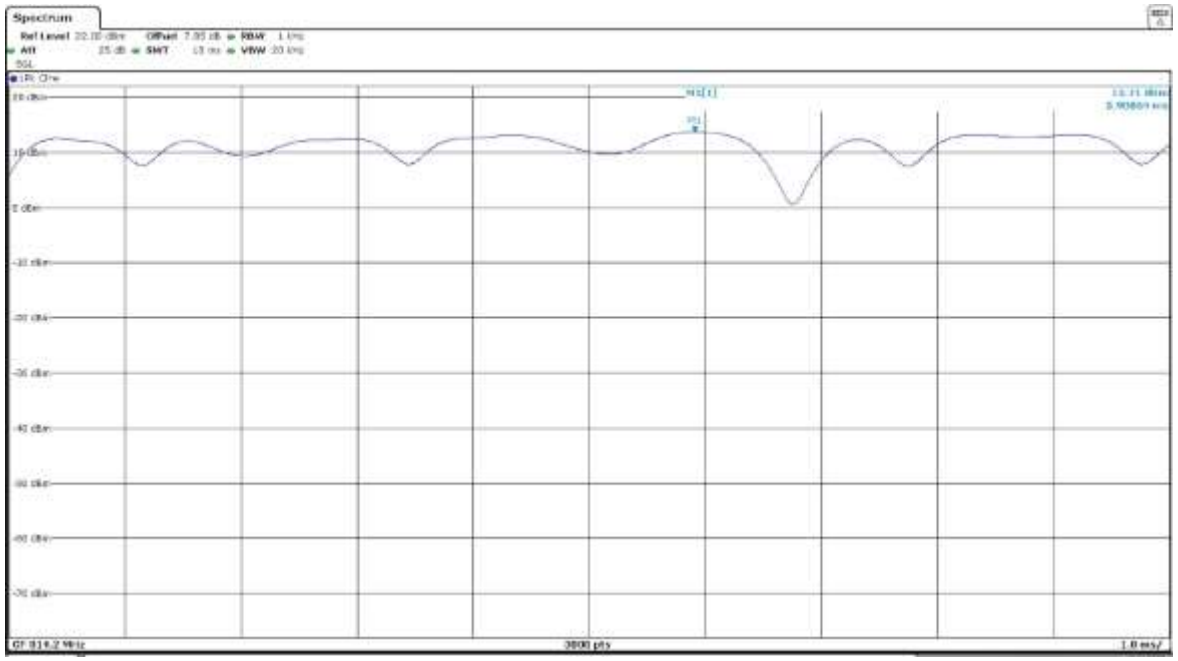
TEST SETUP



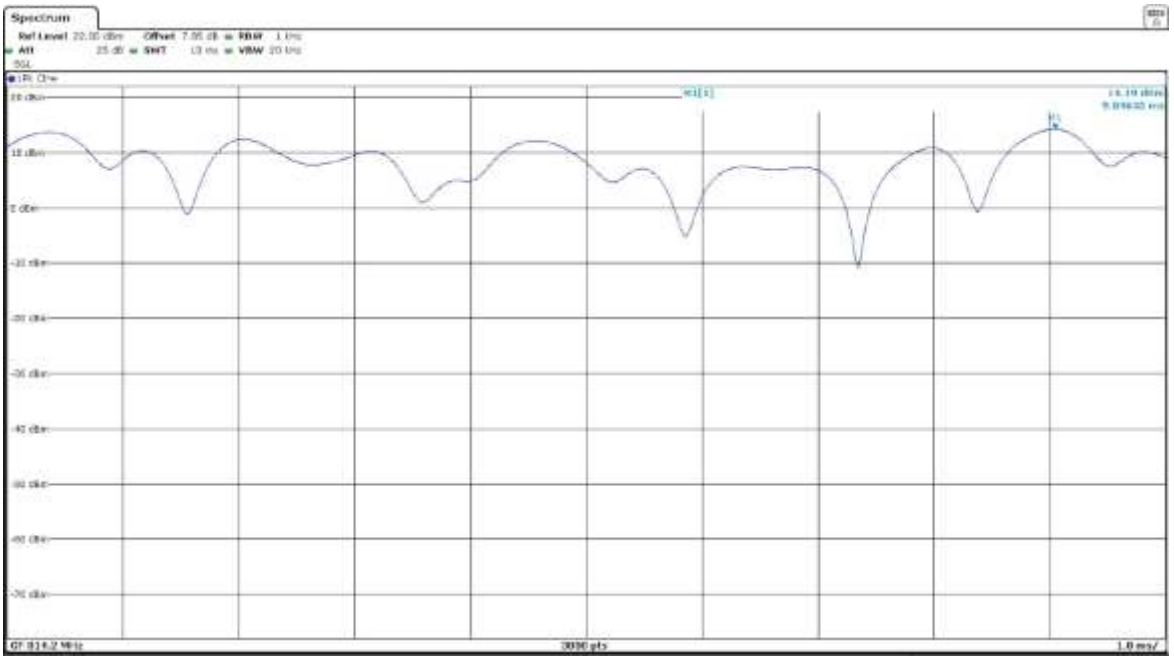
RESULTS

The following plot shows the modulation schemes in the EUT.

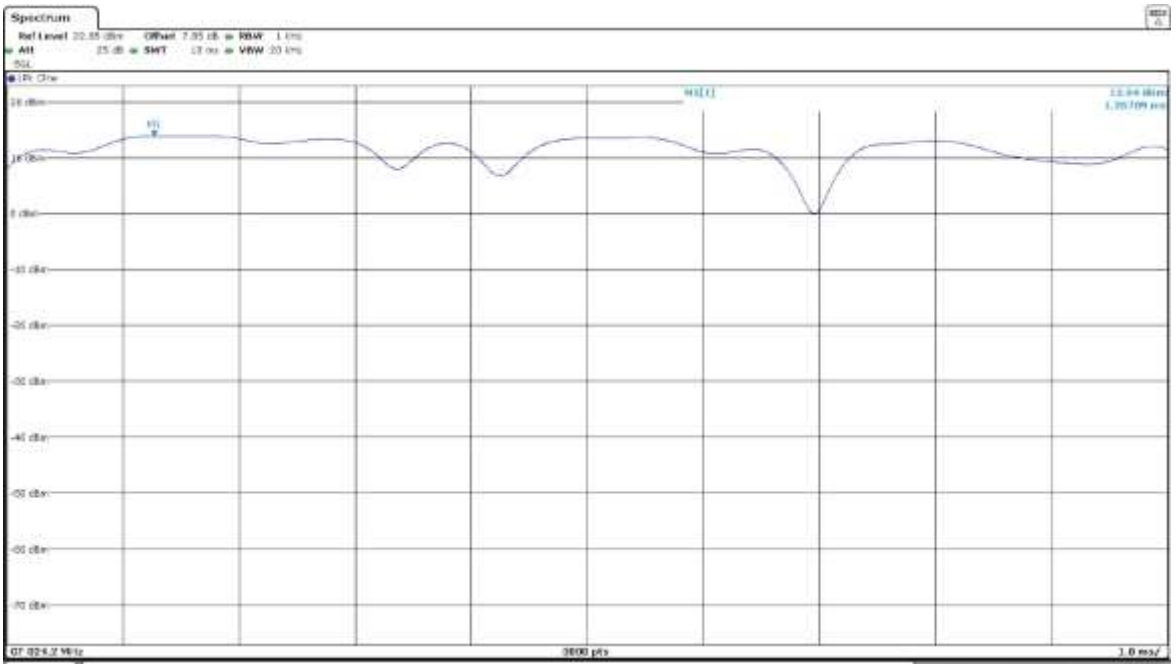
NBIoT MODULATION (Band 26). π/2 - BPSK.



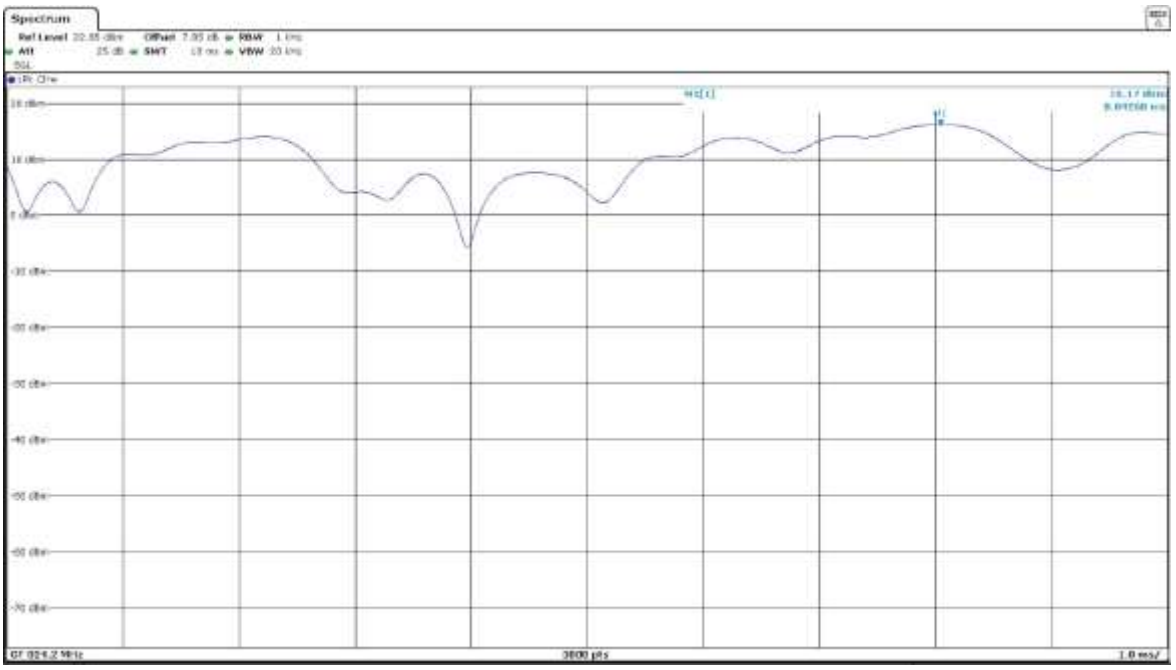
NBIoT MODULATION (Band 26). π/4 - QPSK.



NBIoT MODULATION (Band 5). π/2 - BPSK.



NBIoT MODULATION (Band 5). π/4 - QPSK.



Occupied Bandwidth

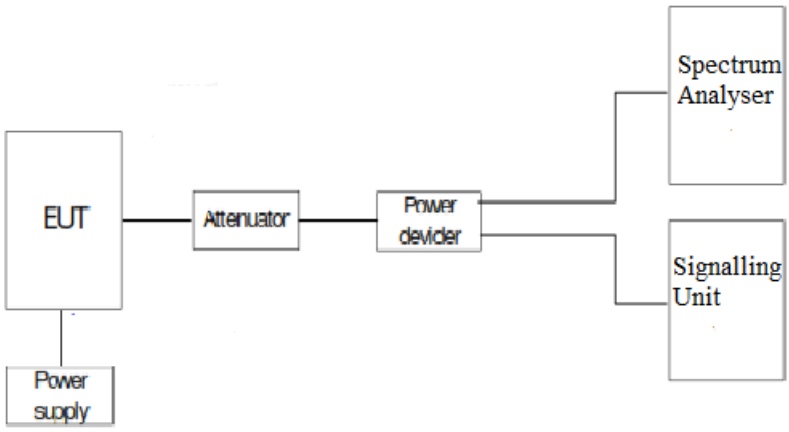
SPECIFICATION

§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 26.

Tone 3.75 kHz. π/2 - BPSK MODULATION

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (kHz)	38.033	38.300	38.366
-26 dBc bandwidth (kHz)	34.833	34.833	34.833
Measurement uncertainty (kHz)	<±0.13		

Tone 3.75 kHz. π/4 - QPSK MODULATION

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (kHz)	38.433	38.600	38.366
-26 dBc bandwidth (kHz)	39.800	39.500	39.333
Measurement uncertainty (kHz)	<±0.13		

Tone 15 kHz. π/2 - BPSK MODULATION

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (kHz)	73.533	73.466	73.333
-26 dBc bandwidth (kHz)	92.267	92.333	92.333
Measurement uncertainty (kHz)	<±0.27		

12 Tones 15 kHz. π/4 - QPSK MODULATION

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (kHz)	190.800	190.400	191.333
-26 dBc bandwidth (kHz)	266.000	266.530	255.470
Measurement uncertainty (kHz)	<±0.65		

NBIoT BAND 26. (824MHz)

Tone 3.75 kHz. π/2 - BPSK MODULATION

99% Occupied bandwidth (kHz)	38.366
-26 dBc bandwidth (kHz)	34.800
Measurement uncertainty (kHz)	<±0.13

Tone 3.75 kHz. π/4 - QPSK MODULATION

99% Occupied bandwidth (kHz)	38.366
-26 dBc bandwidth (kHz)	39.333
Measurement uncertainty (kHz)	<±0.13

Tone 15 kHz. π/2 - BPSK MODULATION

99% Occupied bandwidth (kHz)	73.466
-26 dBc bandwidth (kHz)	92.133
Measurement uncertainty (kHz)	<±0.27

12 Tones 15 kHz. π/4 - QPSK MODULATION

99% Occupied bandwidth (kHz)	190.800
-26 dBc bandwidth (kHz)	255.160
Measurement uncertainty (kHz)	<±0.65

NBIoT BAND 5.

Tone 3.75 kHz. π/2 - BPSK MODULATION

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (kHz)	38.400	38.400	38.233
-26 dBc bandwidth (kHz)	35.400	35.367	35.367
Measurement uncertainty (kHz)	<±0.13		

Tone 3.75 kHz. π/4 - QPSK MODULATION

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (kHz)	38.400	38.600	38.766
-26 dBc bandwidth (kHz)	41.500	41.253	41.223
Measurement uncertainty (kHz)	<±0.13		

Tone 15 kHz. π/2 - BPSK MODULATION

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (kHz)	73.200	73.400	73.333
-26 dBc bandwidth (kHz)	92.333	99.133	92.933
Measurement uncertainty (kHz)	<±0.27		

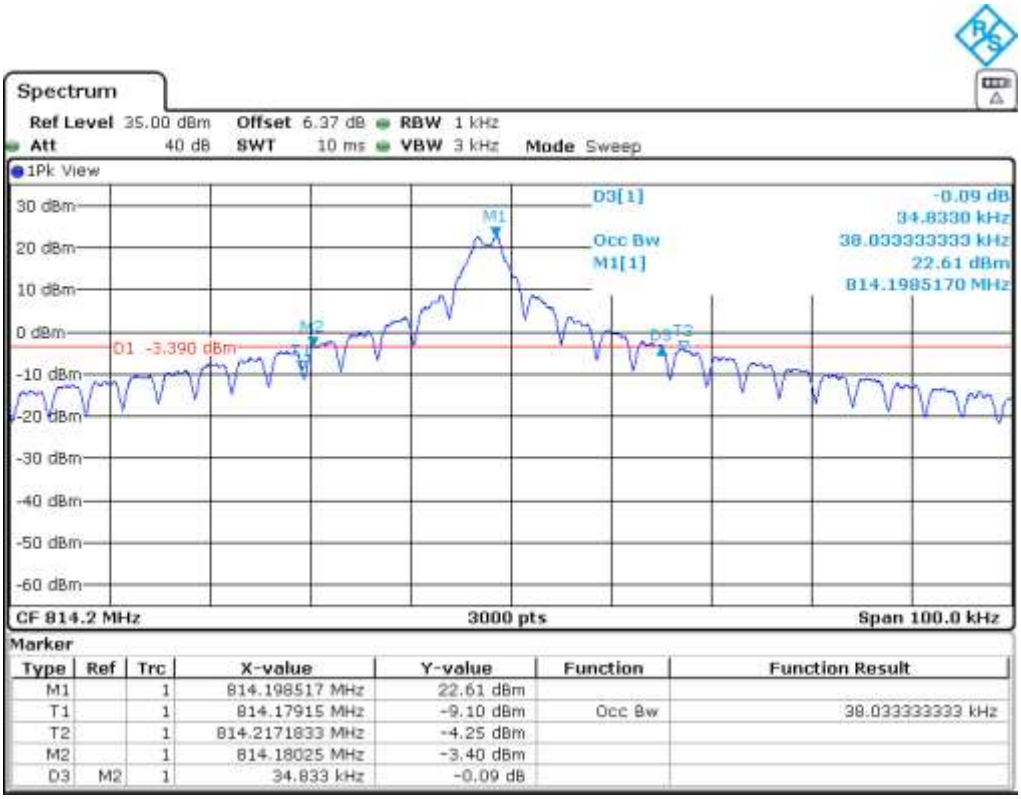
12 Tones 15 kHz. π/4 - QPSK MODULATION

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (kHz)	191.066	190.800	191.200
-26 dBc bandwidth (kHz)	267.870	257.070	270.270
Measurement uncertainty (kHz)	<±0.65		

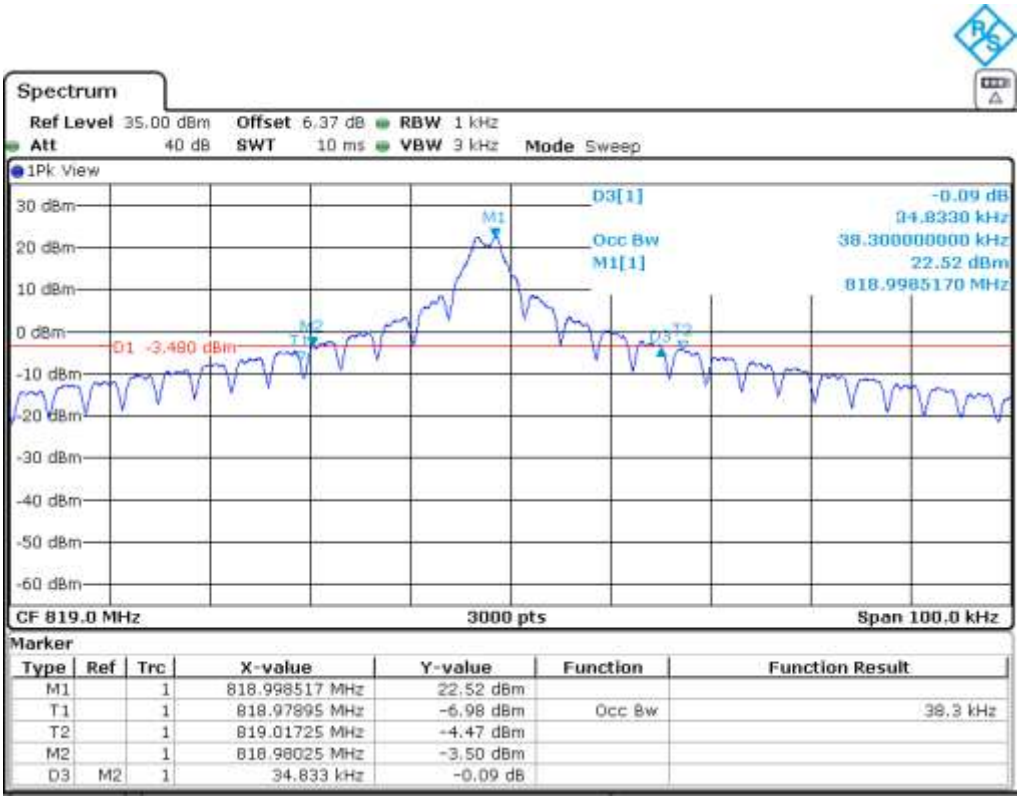
NBIoT BAND 26.

Tone 3.75 kHz. π/2 - BPSK MODULATION

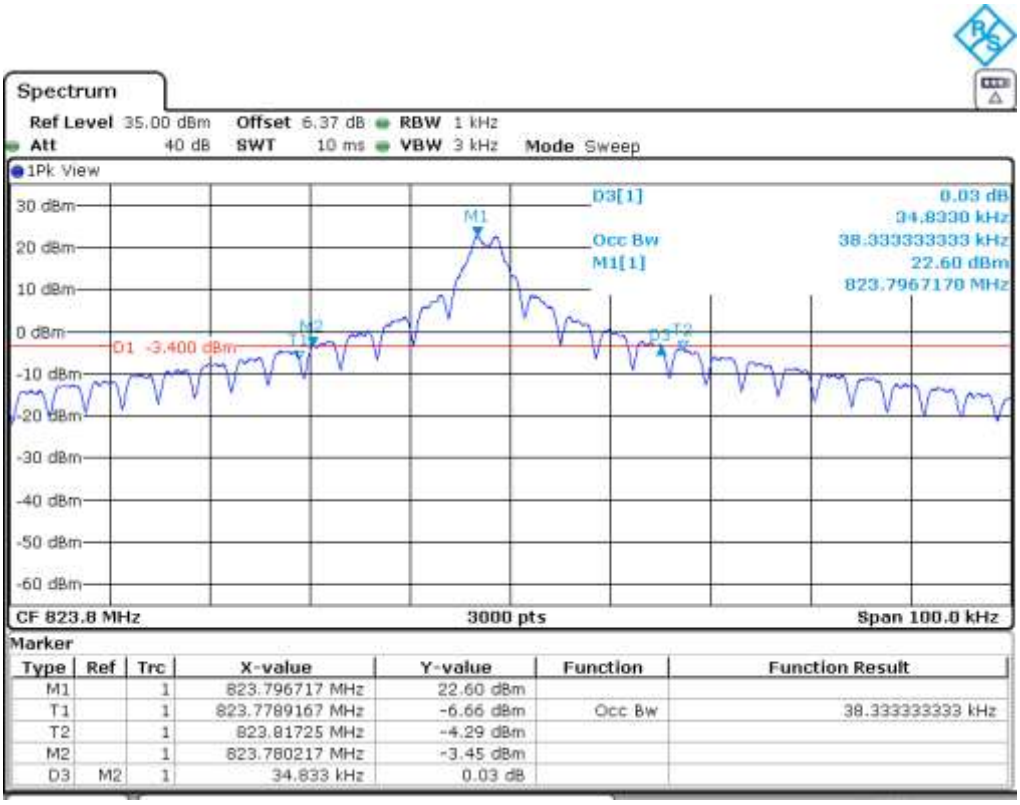
Lowest Channel



Middle Channel

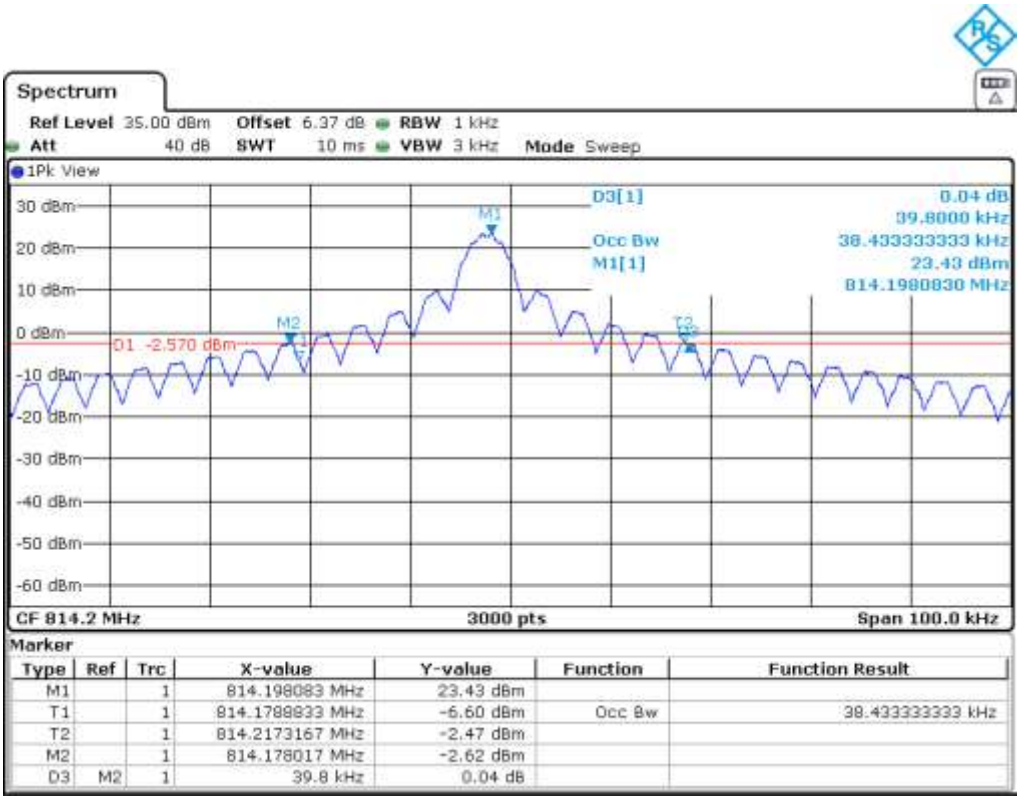


Highest Channel

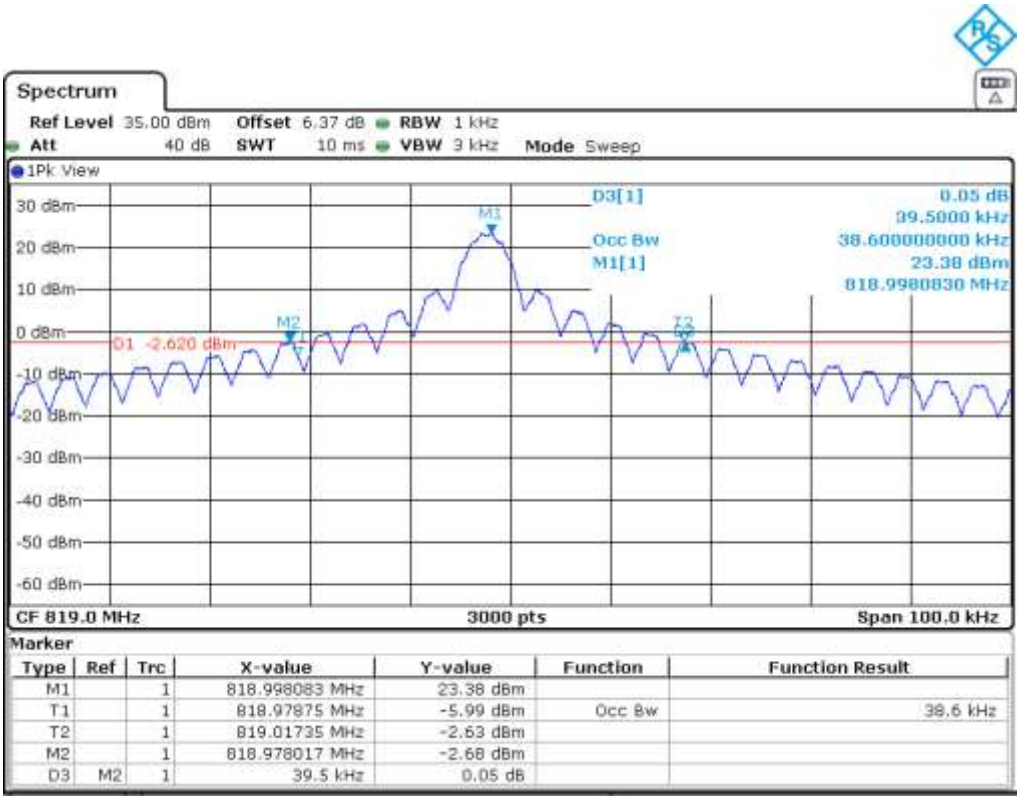


Tone 3.75 kHz. π/4 - QPSK MODULATION

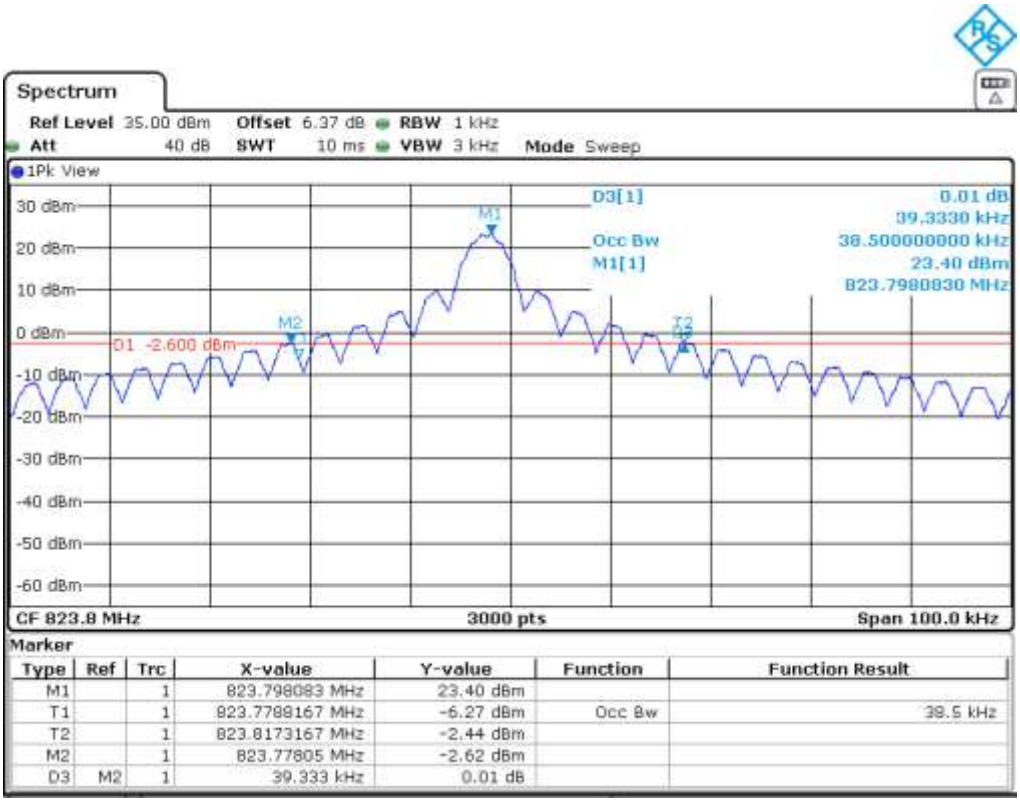
Lowest Channel



Middle Channel

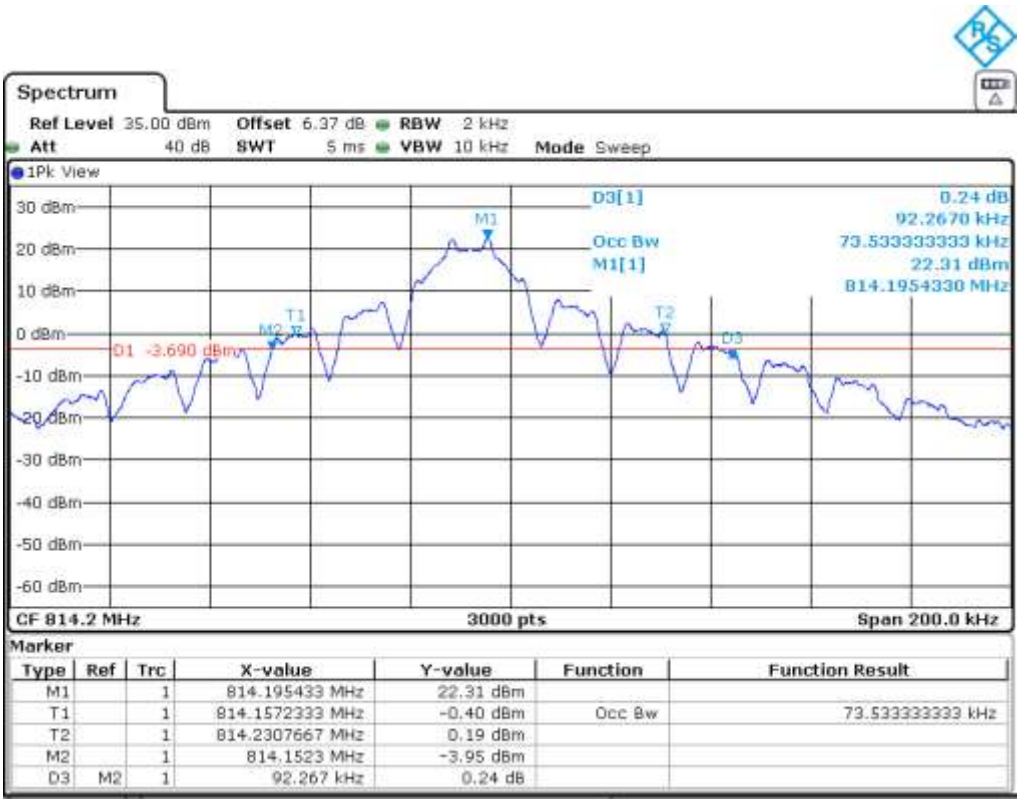


Highest Channel

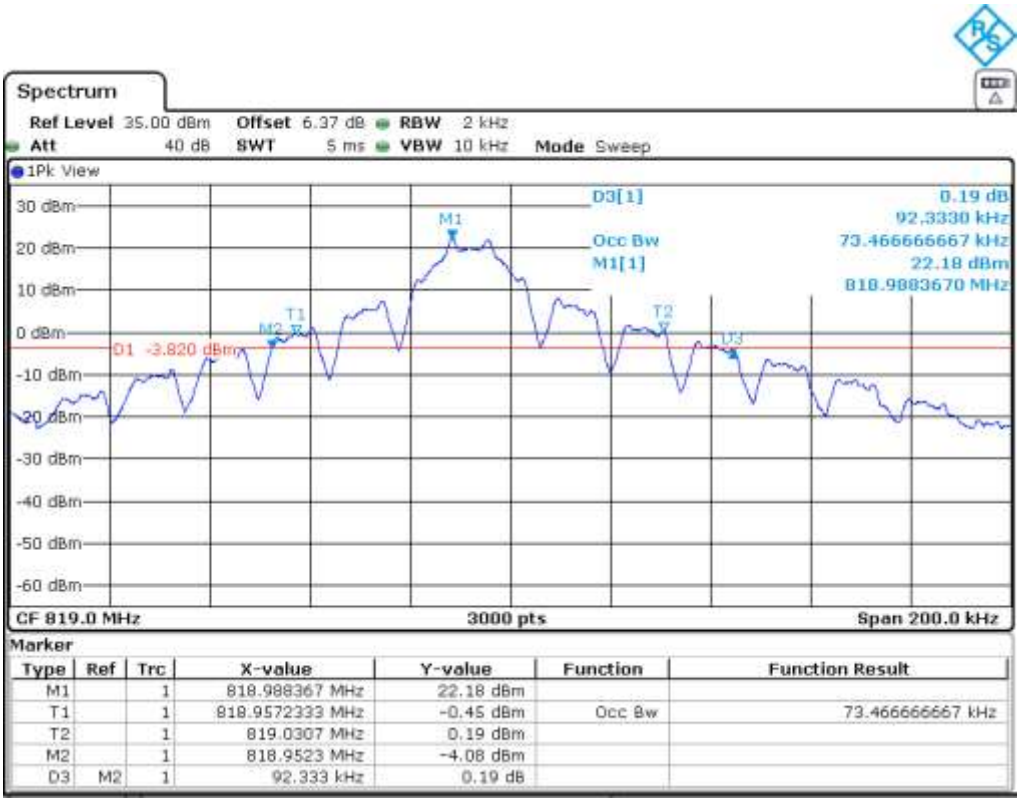


Tone 15 kHz. π/2 - BPSK MODULATION

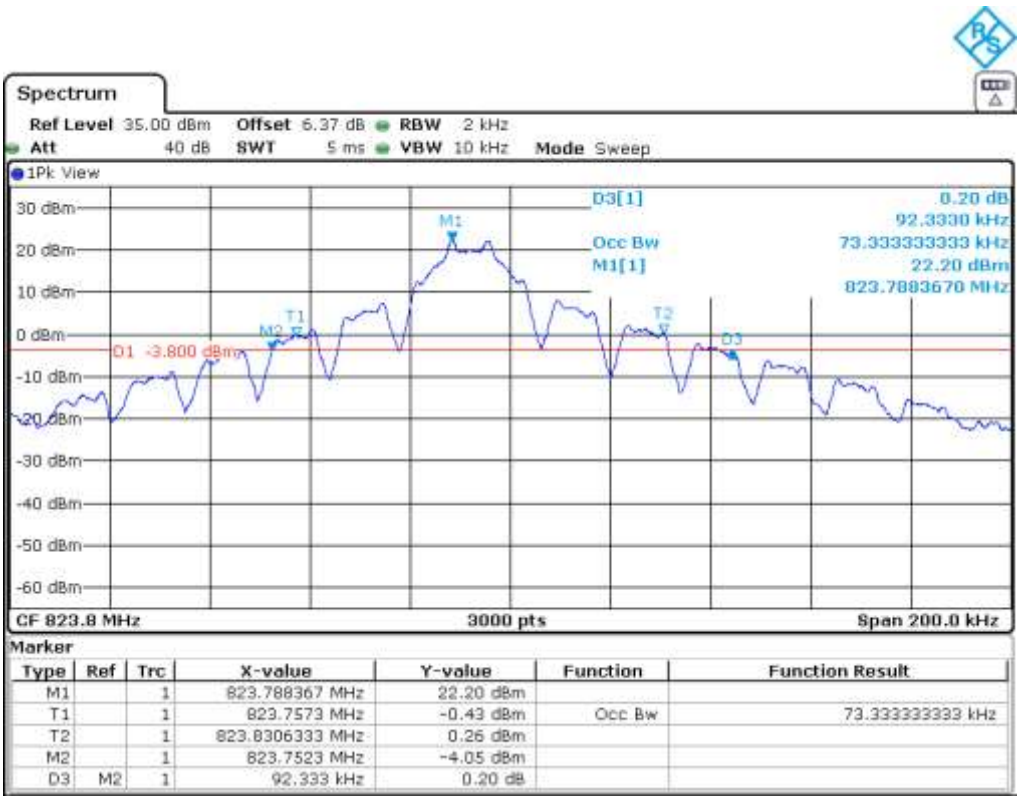
Lowest Channel



Middle Channel

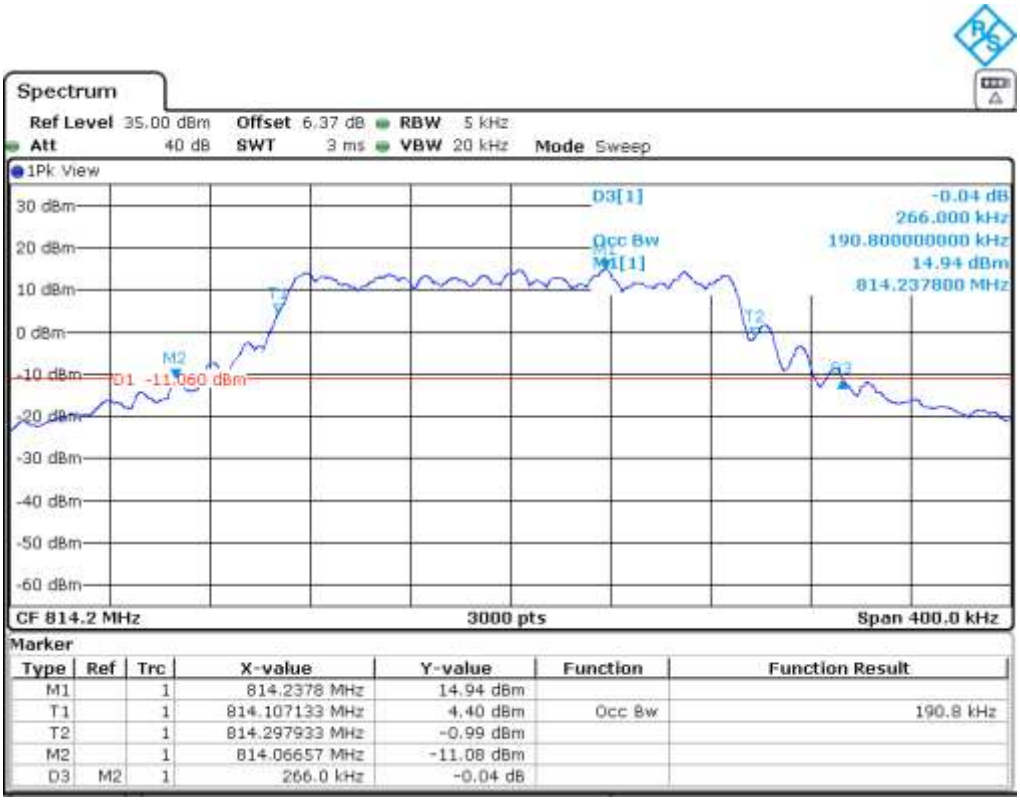


Highest Channel

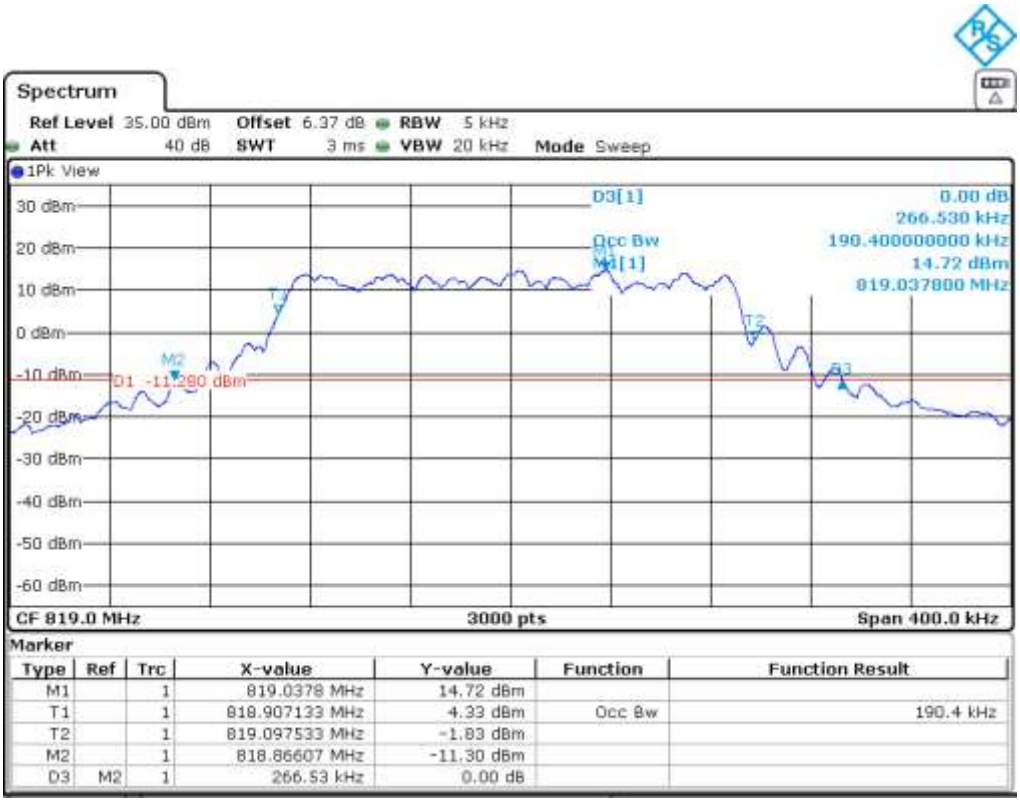


12 Tones 15 kHz. π/4 - QPSK MODULATION

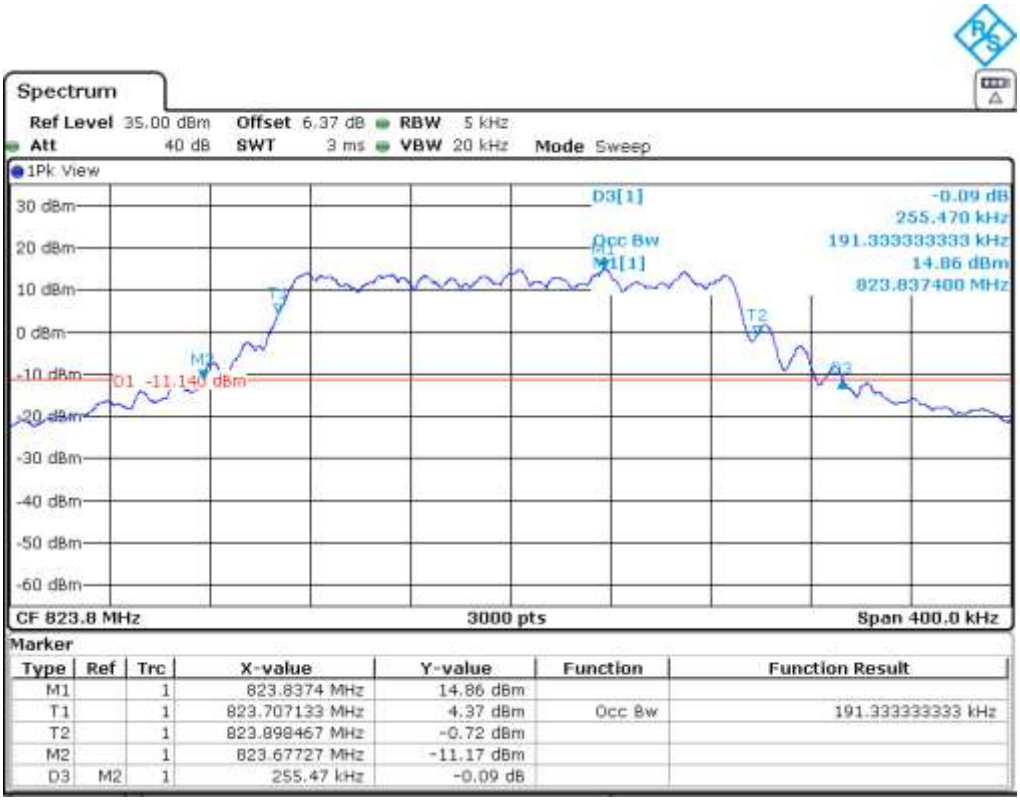
Lowest Channel



Middle Channel



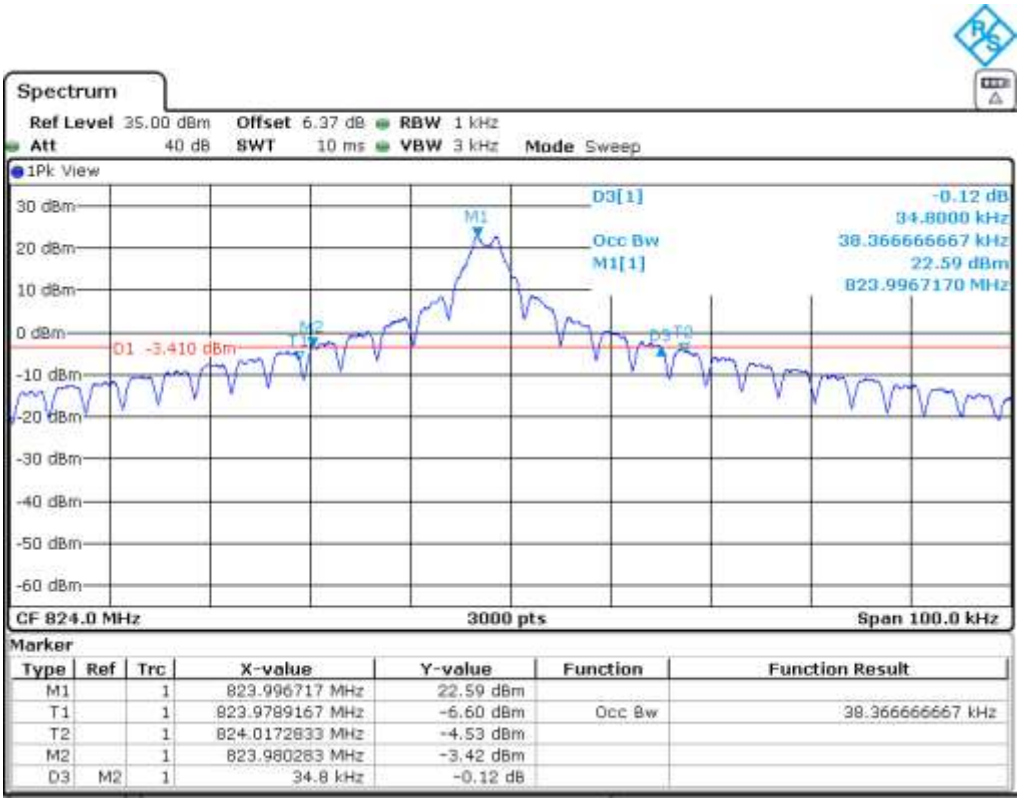
Highest Channel



NBIoT BAND 26.

NBIoT BAND 26 (824MHz).

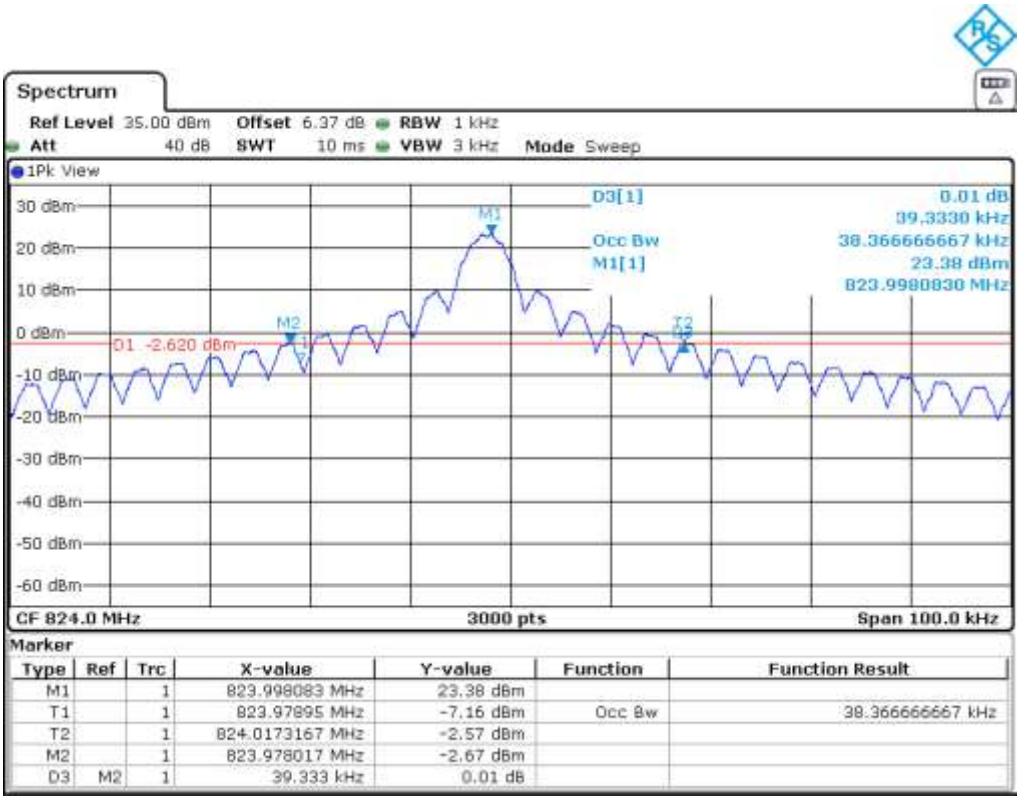
Tone 3.75 kHz. π/2 - BPSK MODULATION



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	823.996717 MHz	22.59 dBm		
T1		1	823.9789167 MHz	-6.60 dBm	Occ Bw	38.366666667 kHz
T2		1	824.0172833 MHz	-4.53 dBm		
M2		1	823.980283 MHz	-3.42 dBm		
D3	M2	1	34.8 kHz	-0.12 dB		

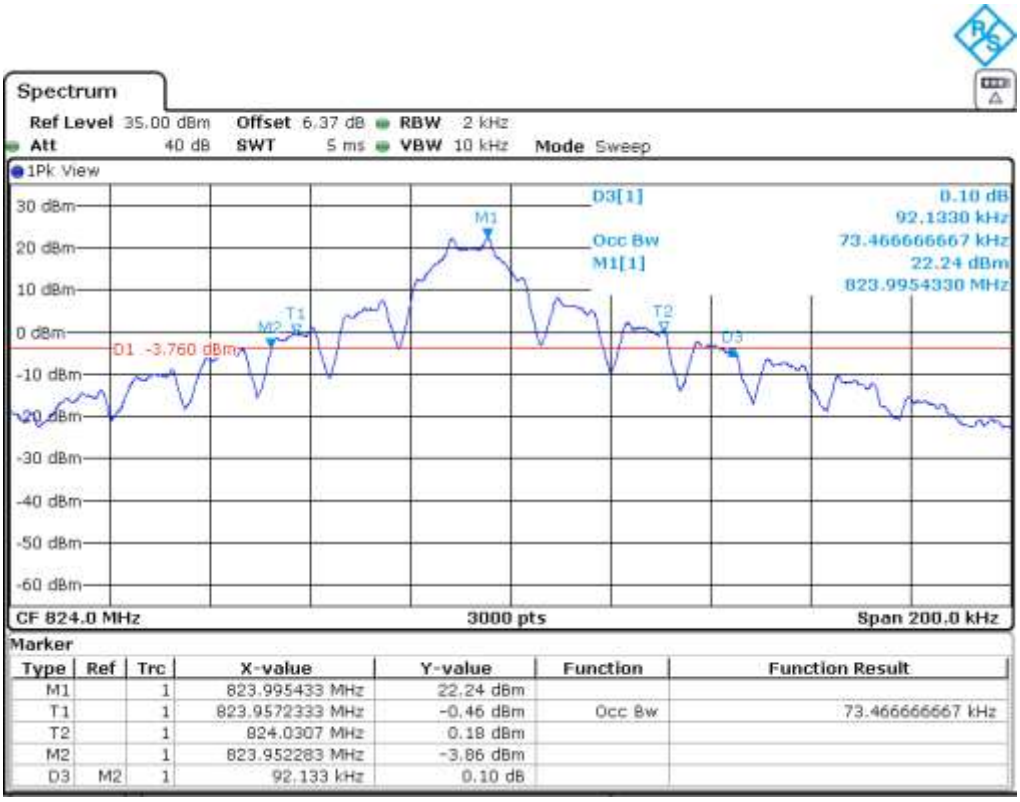
Tone 3.75 kHz. π/4 - QPSK MODULATION



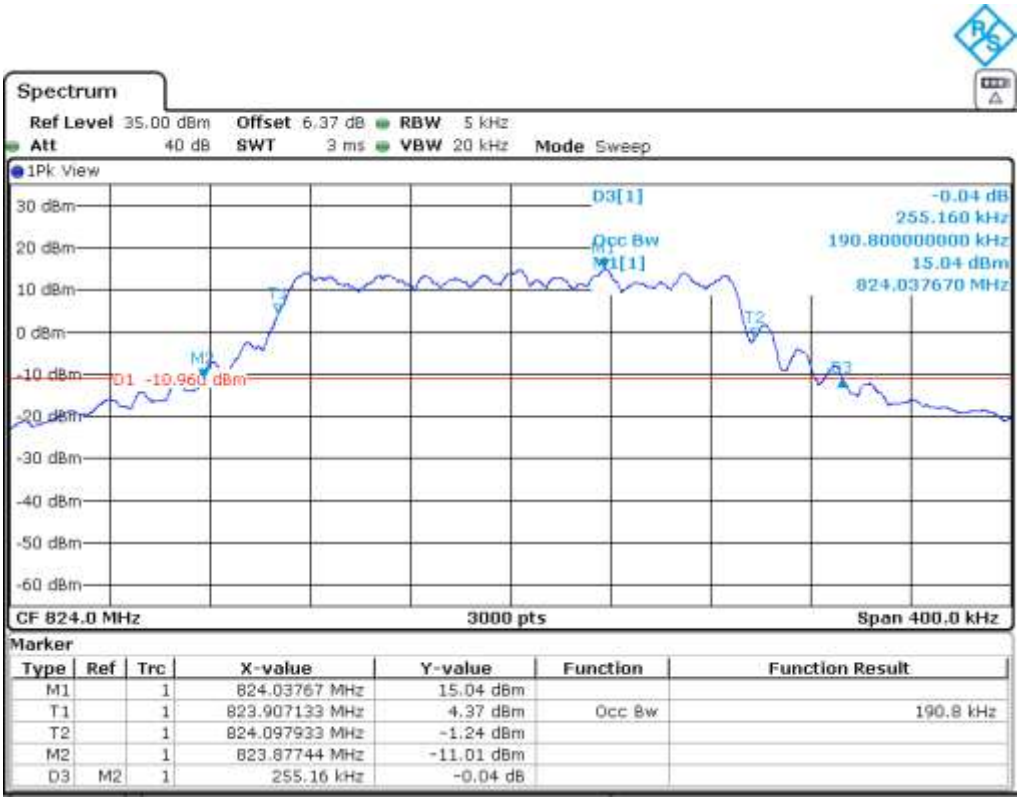
Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	823.998083 MHz	23.38 dBm		
T1		1	823.97895 MHz	-7.16 dBm	Occ Bw	38.366666667 kHz
T2		1	824.0173167 MHz	-2.57 dBm		
M2		1	823.978017 MHz	-2.67 dBm		
D3	M2	1	39.333 kHz	0.01 dB		

Tone 15 kHz. π/2 - BPSK MODULATION



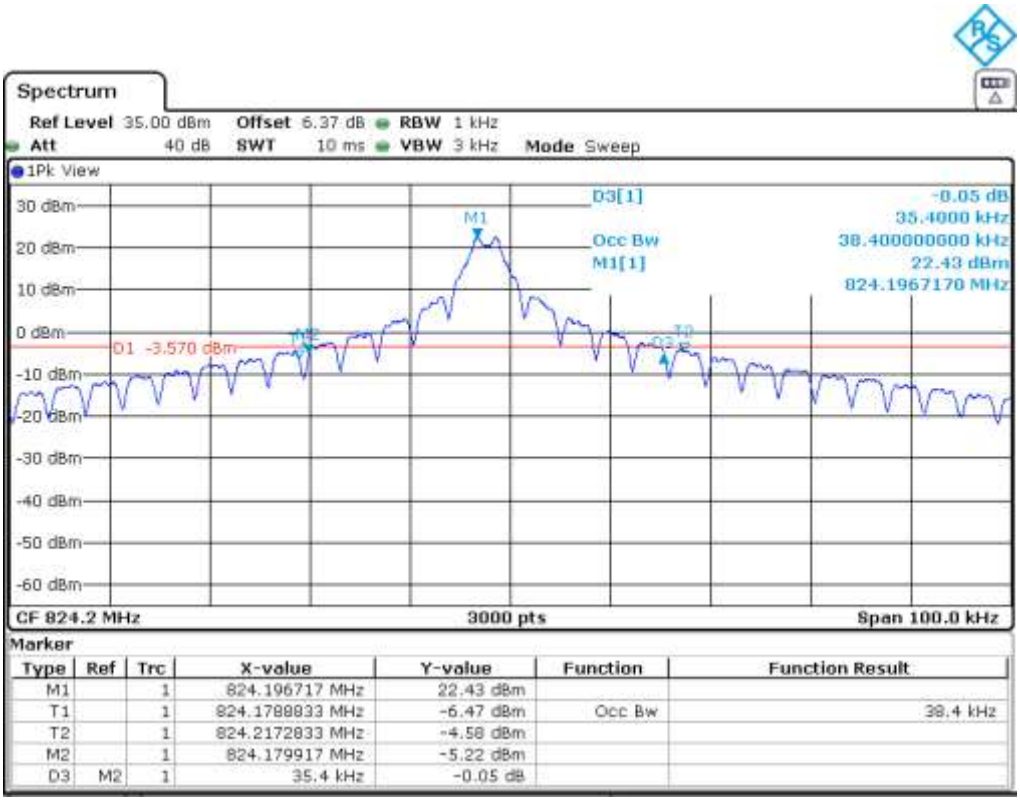
12 Tones 15 kHz. π/4 - QPSK MODULATION



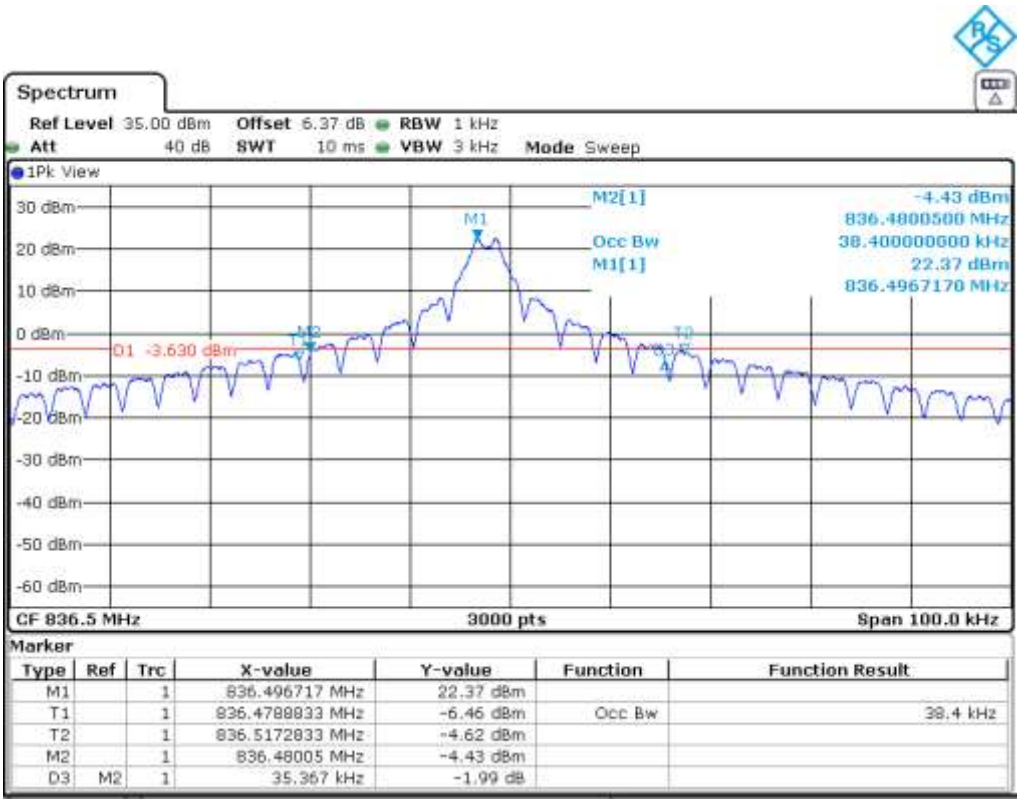
NBIoT BAND 5.

Tone 3.75 kHz. π/2 - BPSK MODULATION

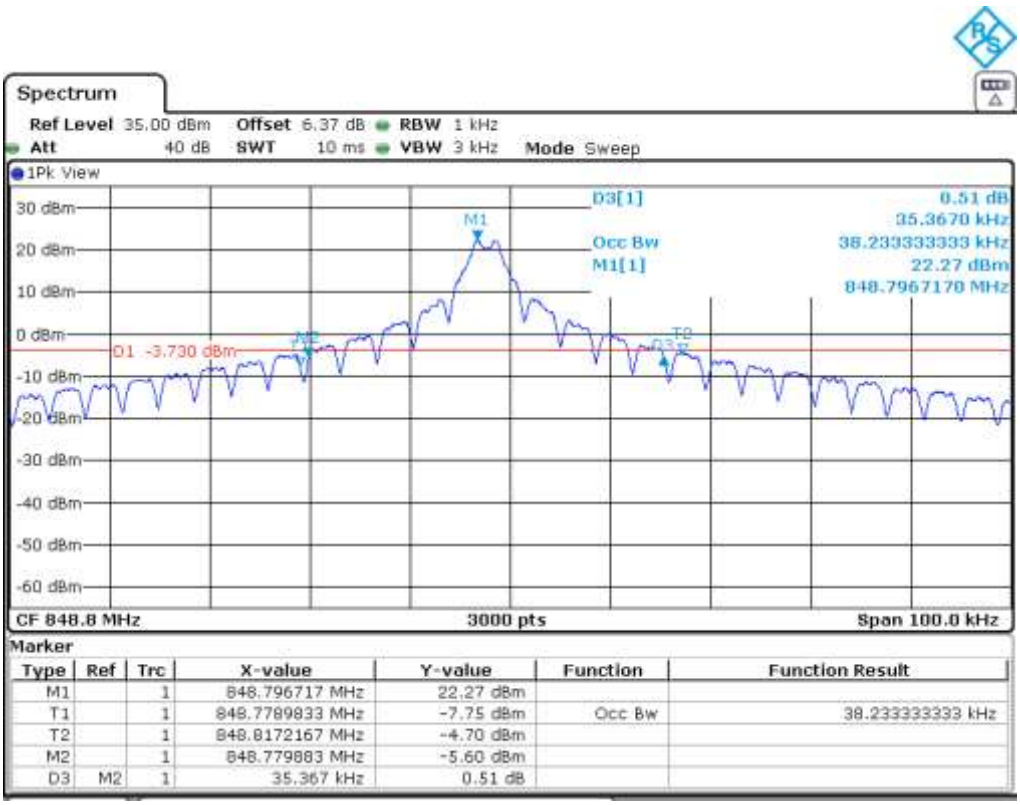
Lowest Channel



Middle Channel

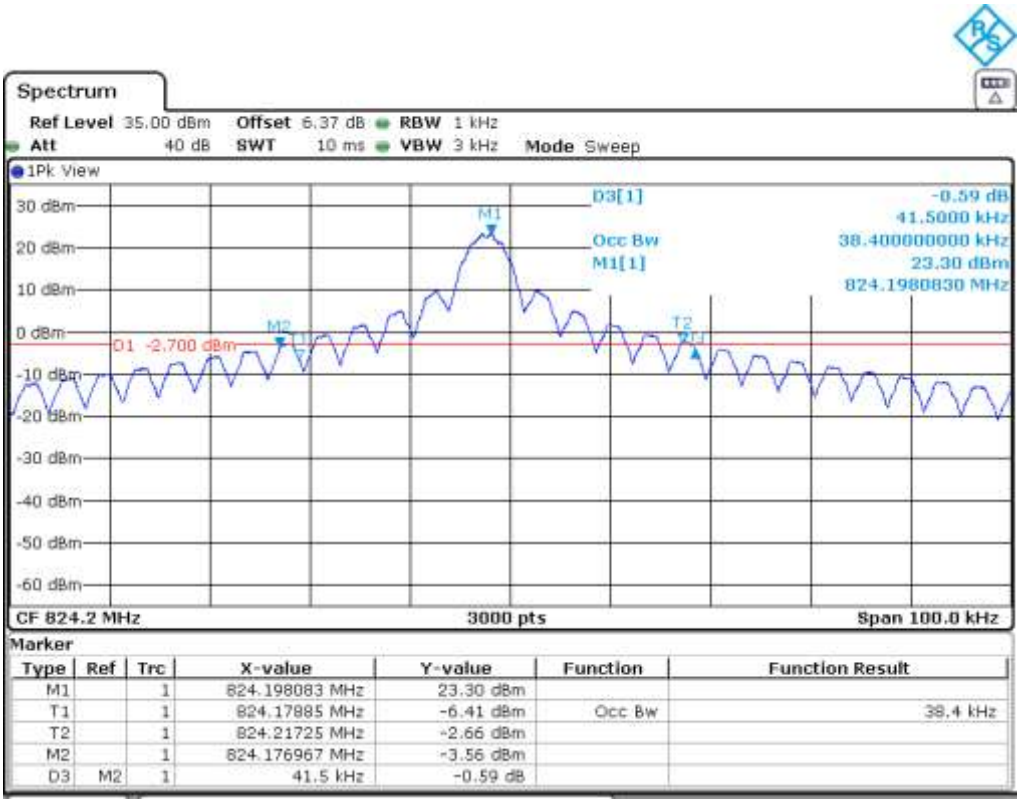


Highest Channel

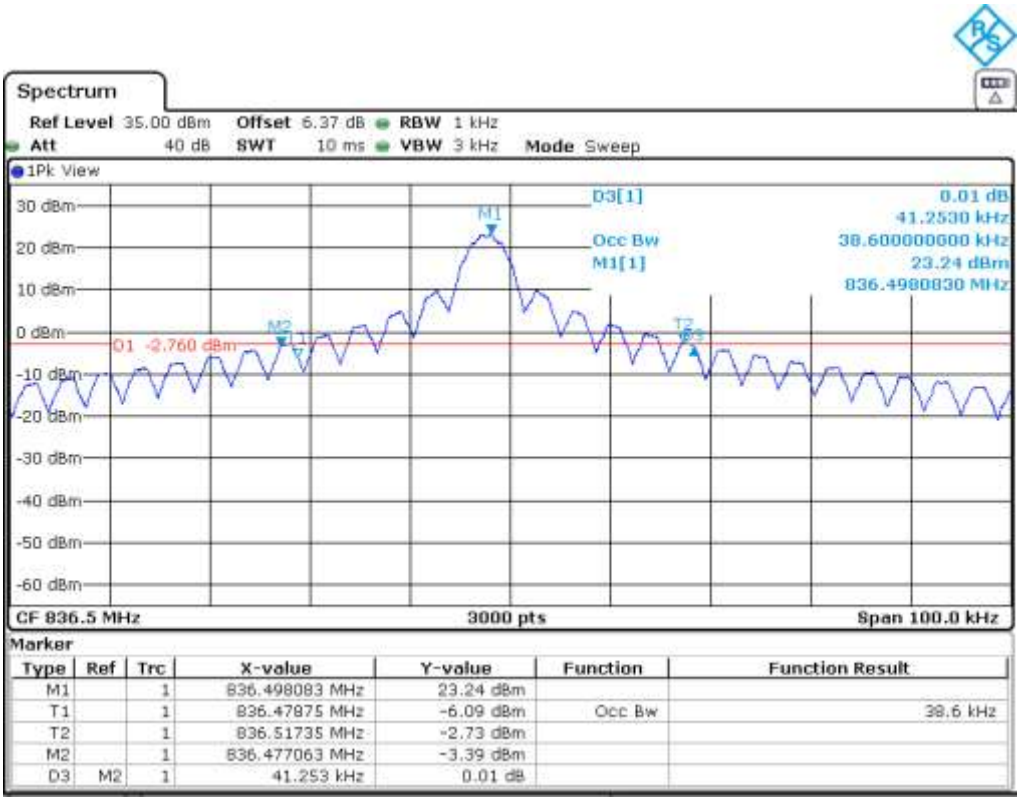


Tone 3.75 kHz. π/4 - QPSK MODULATION

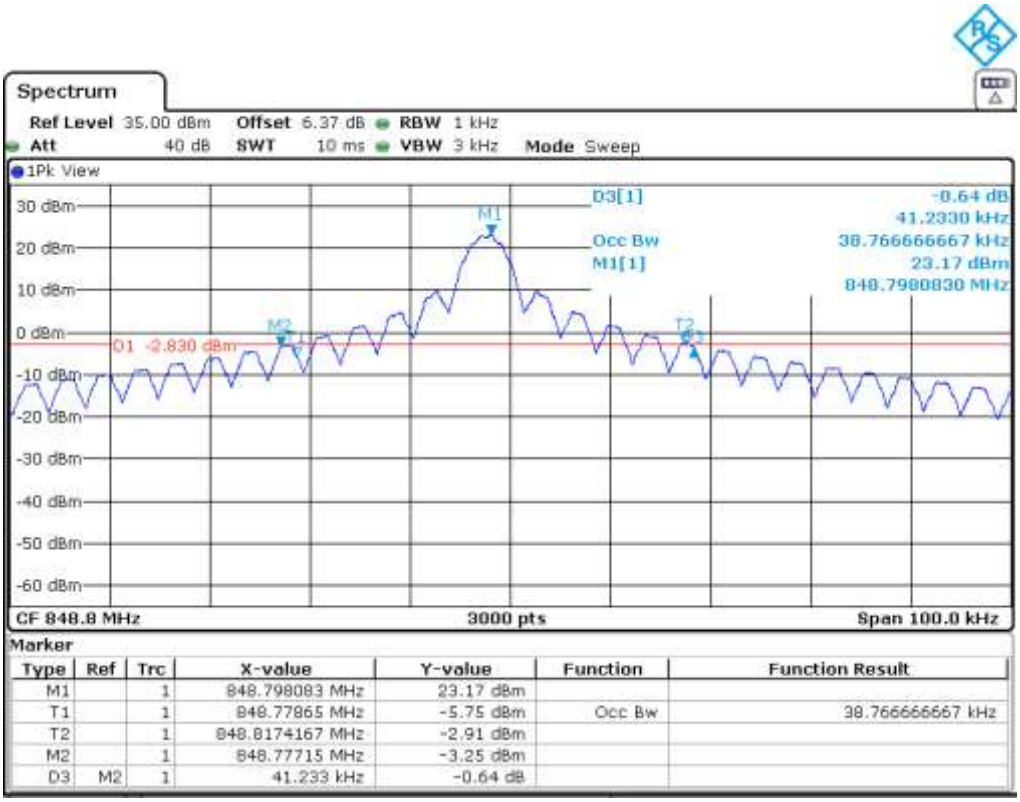
Lowest Channel



Middle Channel

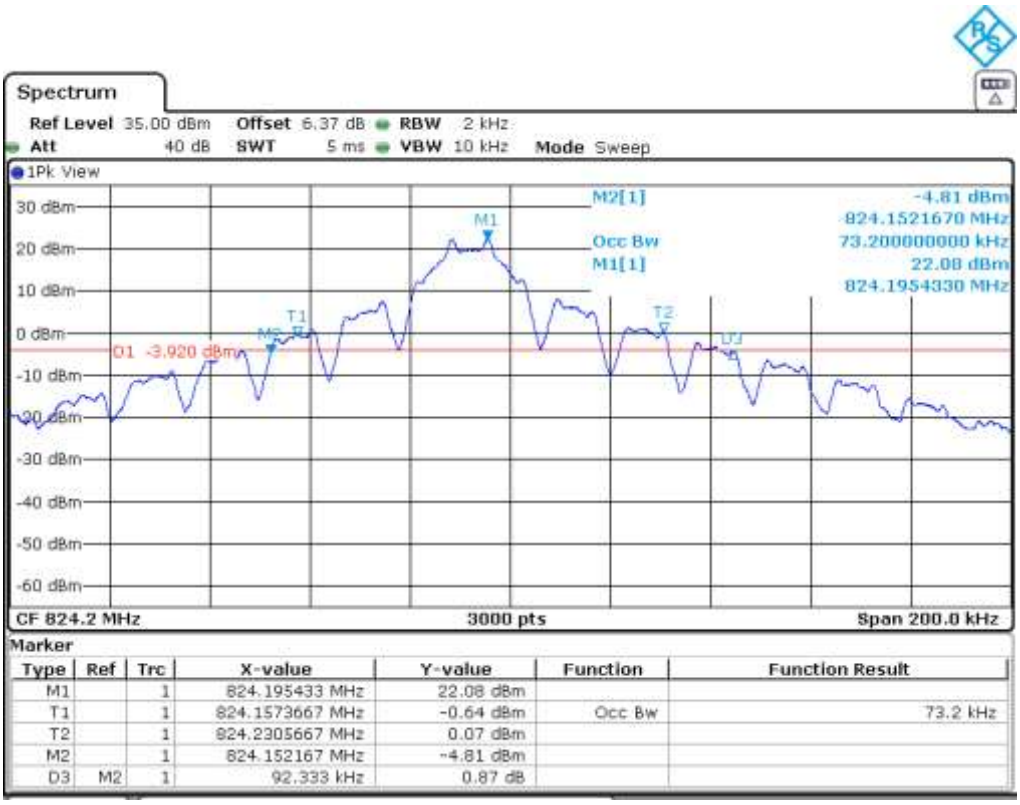


Highest Channel

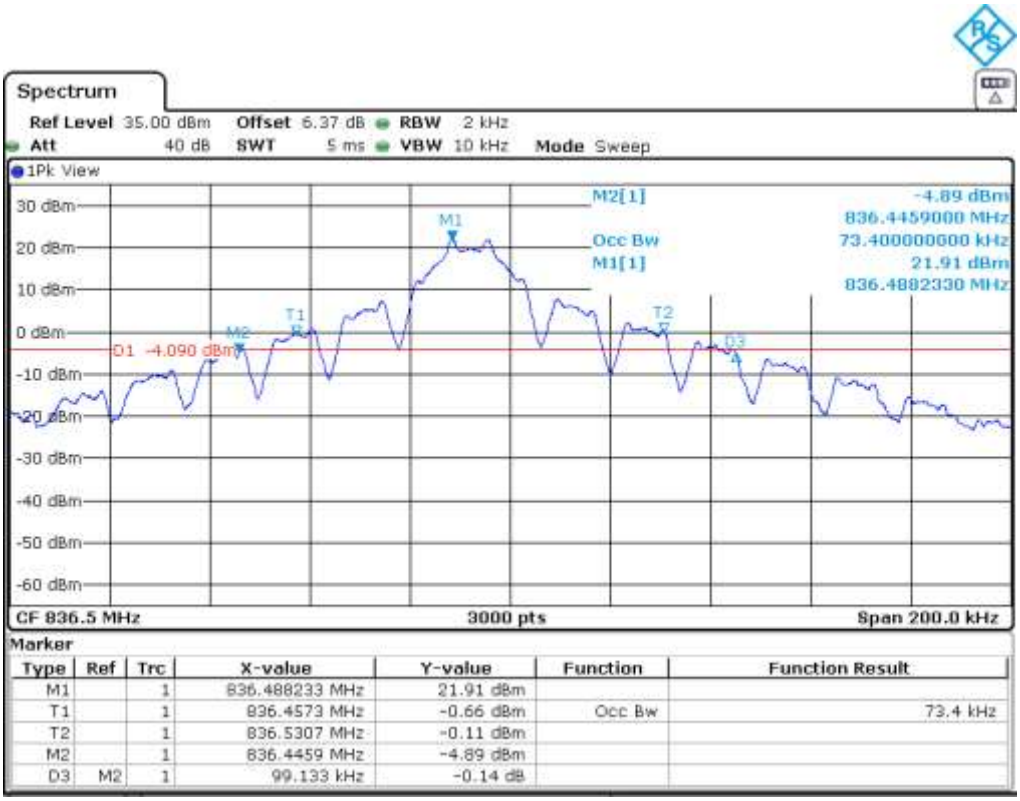


Tone 15 kHz. π/2 - BPSK MODULATION

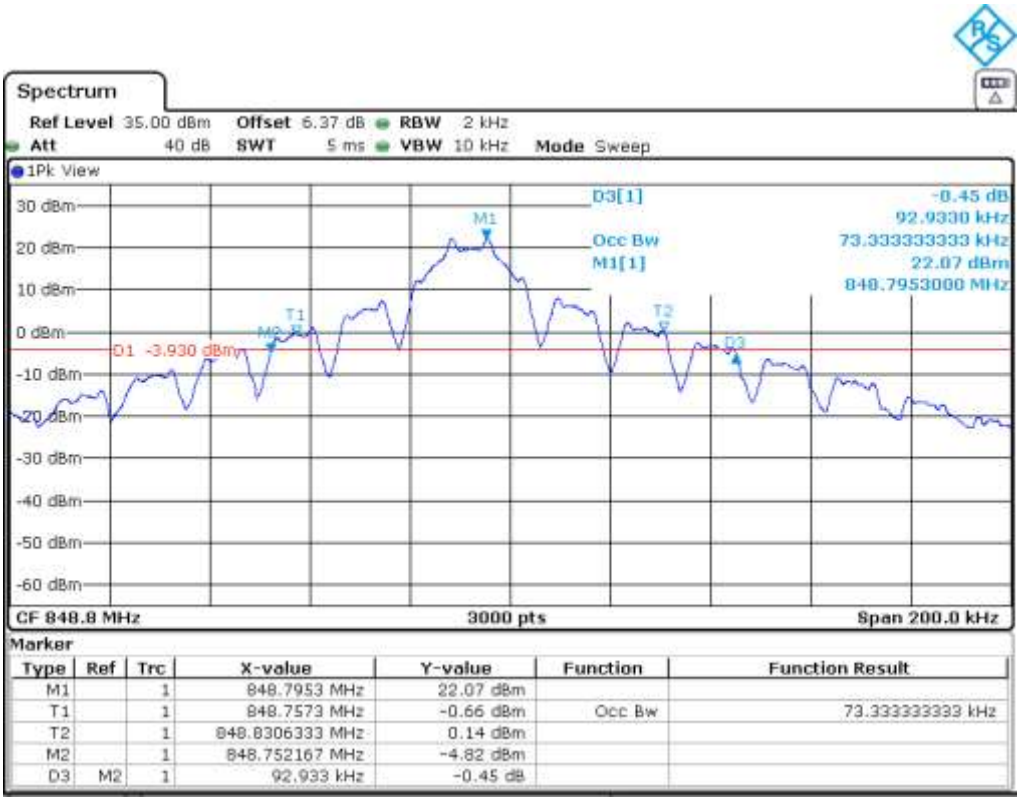
Lowest Channel



Middle Channel

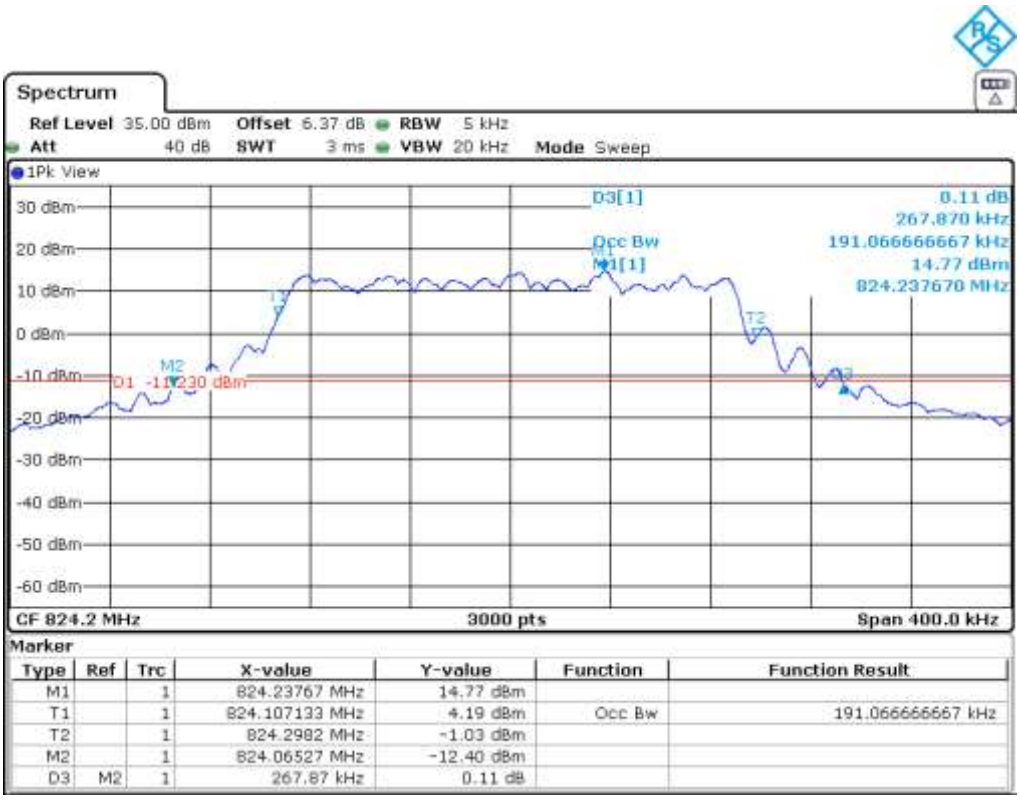


Highest Channel

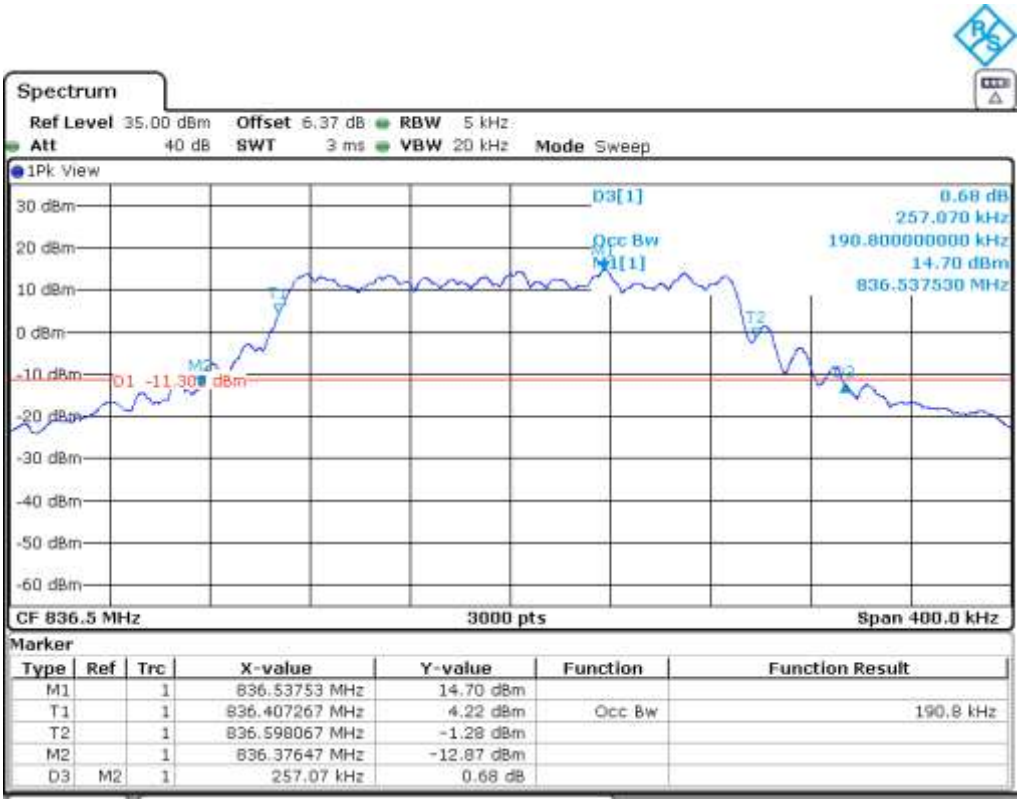


12 Tones 15 kHz. π/4 - QPSK MODULATION

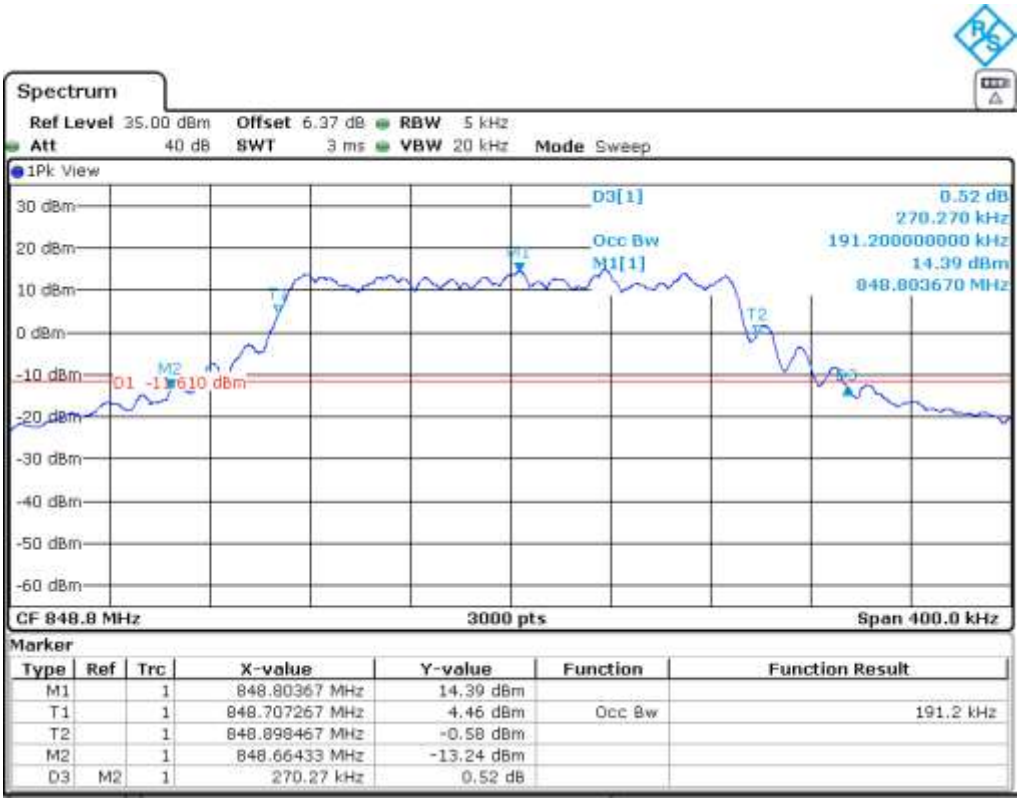
Lowest Channel



Middle Channel



Highest Channel



Spurious emissions at antenna terminals

SPECIFICATION:

FCC §2.1051 and §22.917

RSS-132. Clause 5.5.

FCC §90.543 (e) (2) (3) & (5):

(e) For operations in the 758-768 MHz and the 788-798 MHz bands, the power of any emission outside the 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, in accordance with the following:

(2) On all frequencies between 769-775 MHz and 799-805 MHz, by a factor not less than 65 + 10 log (P) dB in a 6.25 kHz band segment, for mobile and portable stations.

(3) On any frequency between 775-788 MHz, above 805 MHz, and below 758 MHz, by at least 43 + 10 log (P) dB.

(5) Compliance with the provisions of paragraph (e)(3) of this section is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kHz or greater. However, in the 100 kHz bands immediately outside and adjacent to the frequency block, a resolution bandwidth of 30 kHz may be employed.

FCC §90.691:

(a) Out-of-band emission requirement shall apply only to the “outer” channels included in an EA license and to spectrum adjacent to interior channels used by incumbent licensees. The emission limits are as follows:

(1) For any frequency removed from the EA licensee's frequency block by up to and including 37.5 kHz, the power of any emission shall be attenuated below the transmitter power (P) in watts by at least 116 Log10(f/6.1) decibels or 50 + 10 Log10(P) decibels or 80 decibels, whichever is the lesser attenuation, where f is the frequency removed from the center of the outer channel in the block in kilohertz and where f is greater than 12.5 kHz.

(2) For any frequency removed from the EA licensee's frequency block greater than 37.5 kHz, the power of any emission shall be attenuated below the transmitter power (P) in watts by at least 43 + 10Log10(P) decibels or 80 decibels, whichever is the lesser attenuation, where f is the frequency removed from the center of the outer channel in the block in kilohertz and where f is greater than 37.5 kHz.

(b) When an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in this section.

METHOD:

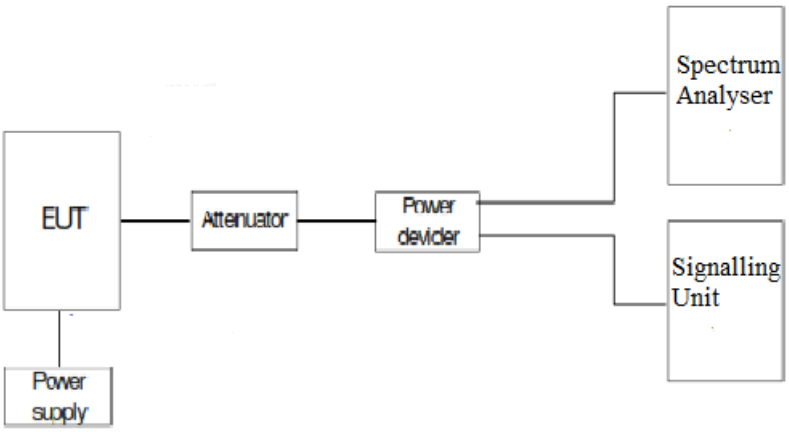
The EUT RF output connector was connected to a spectrum analyser and to the Universal Radio Communication tester R&S CMW500 (selecting maximum transmission power of the EUT and different modes of modulation) using a 50 ohm attenuator and a power divider.

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.

TEST SETUP:



RESULTS (see plots in next pages)

814-824MHz Band:

NBIoT BAND 26 (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 26 (Tone 15 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.

Cross-rule channel (824MHz):

NBIoT BAND 26 (Tone 3.75 kHz. π/2 - BPSK MODULATION)

All peaks are more than 20 dB below the limit.

NBIoT BAND 26 (Tone 15 kHz. π/2 - BPSK MODULATION)

All peaks are more than 20 dB below the limit.

824-849MHz Band:

NBIoT BAND 5 (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 5 (Tone 15 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.

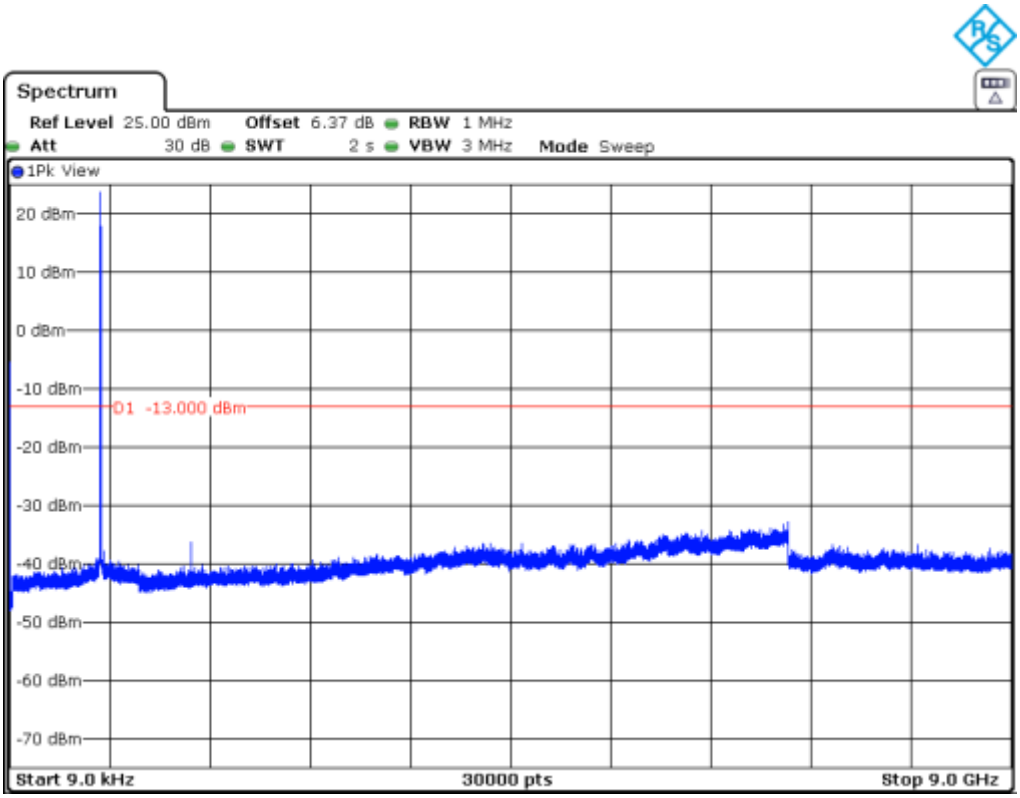
Measurement uncertainty (dB): < ± 2.76

Verdict: PASS

814-824MHz Band:

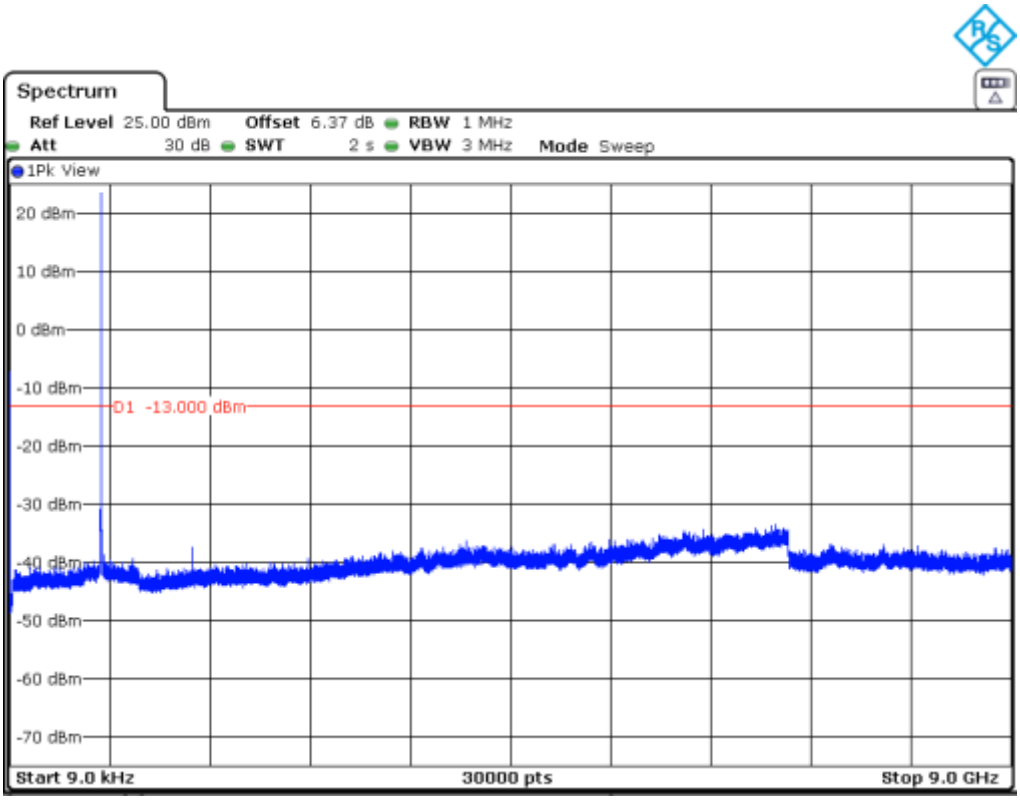
NBIoT BAND 26 (Tone 3.75 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST



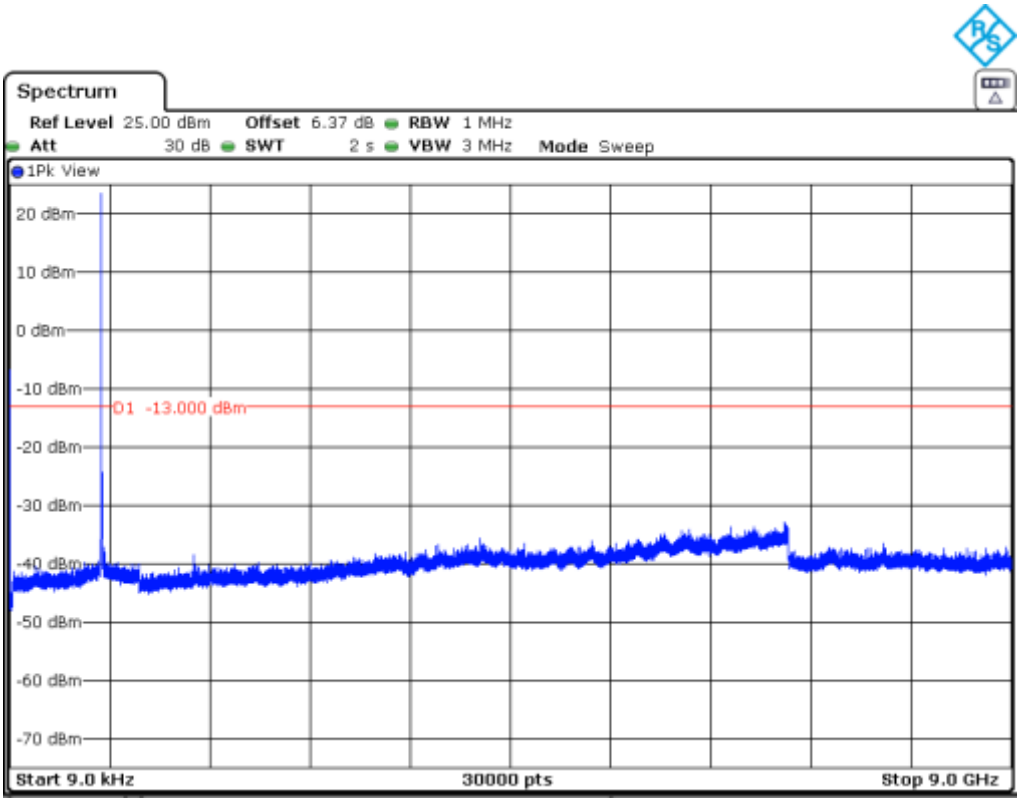
Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE



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

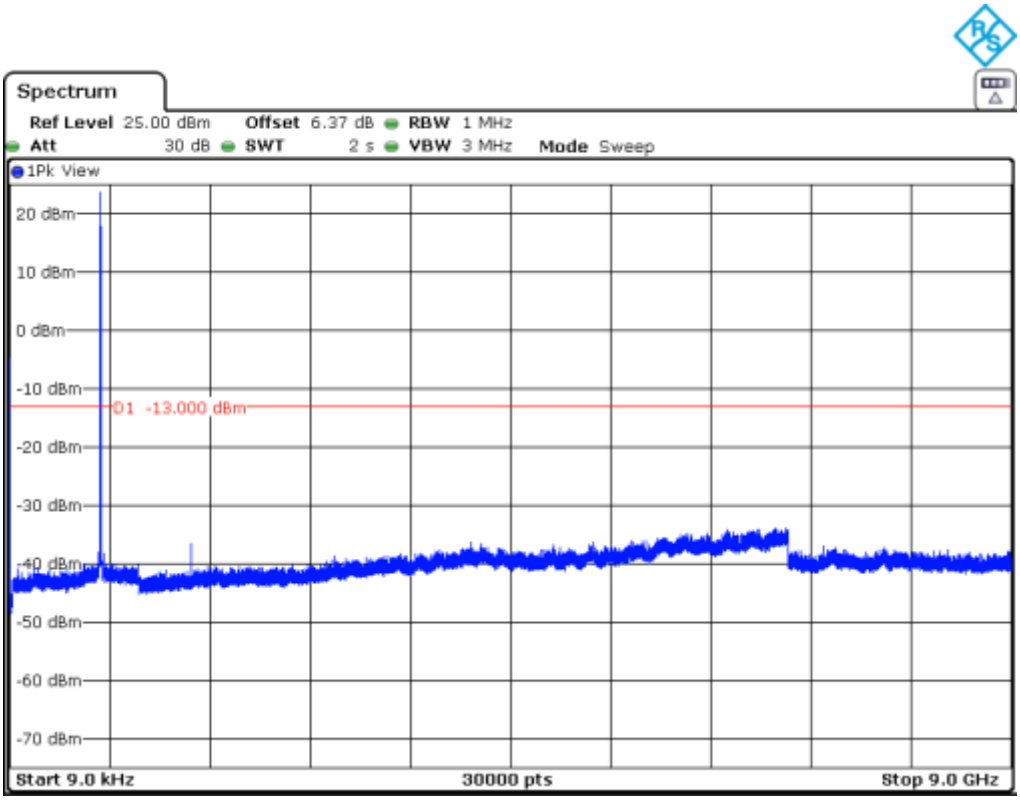
3. CHANNEL: HIGHEST



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

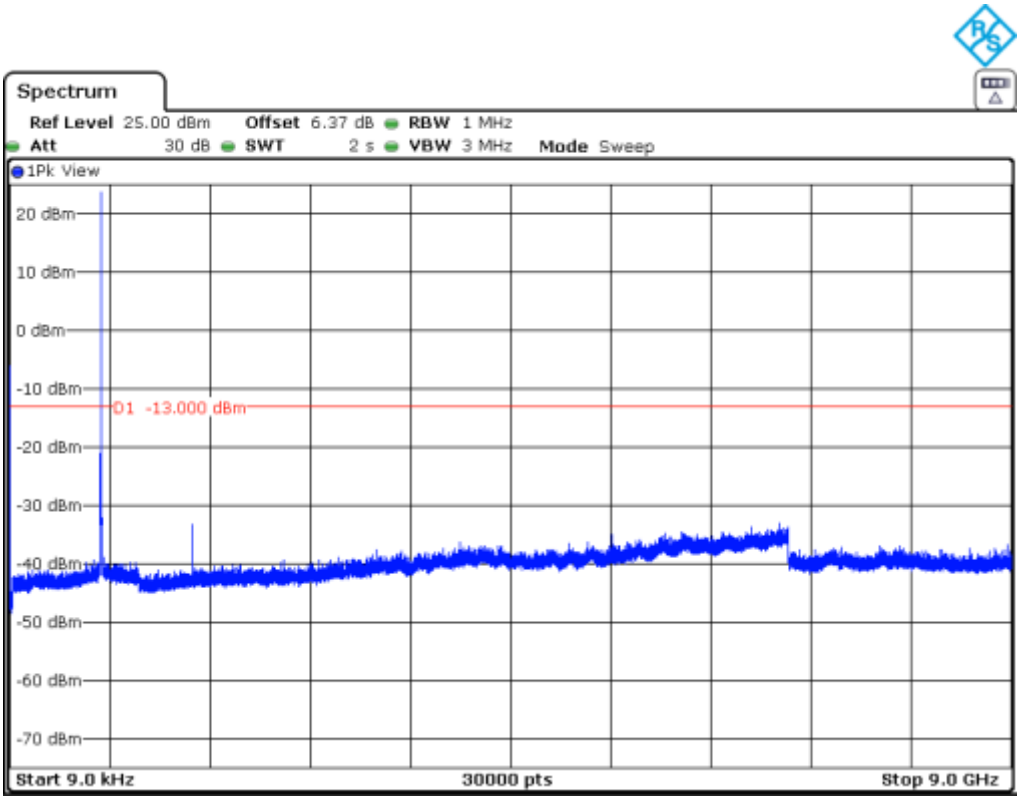
NBIoT BAND 26 (Tone 15 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST



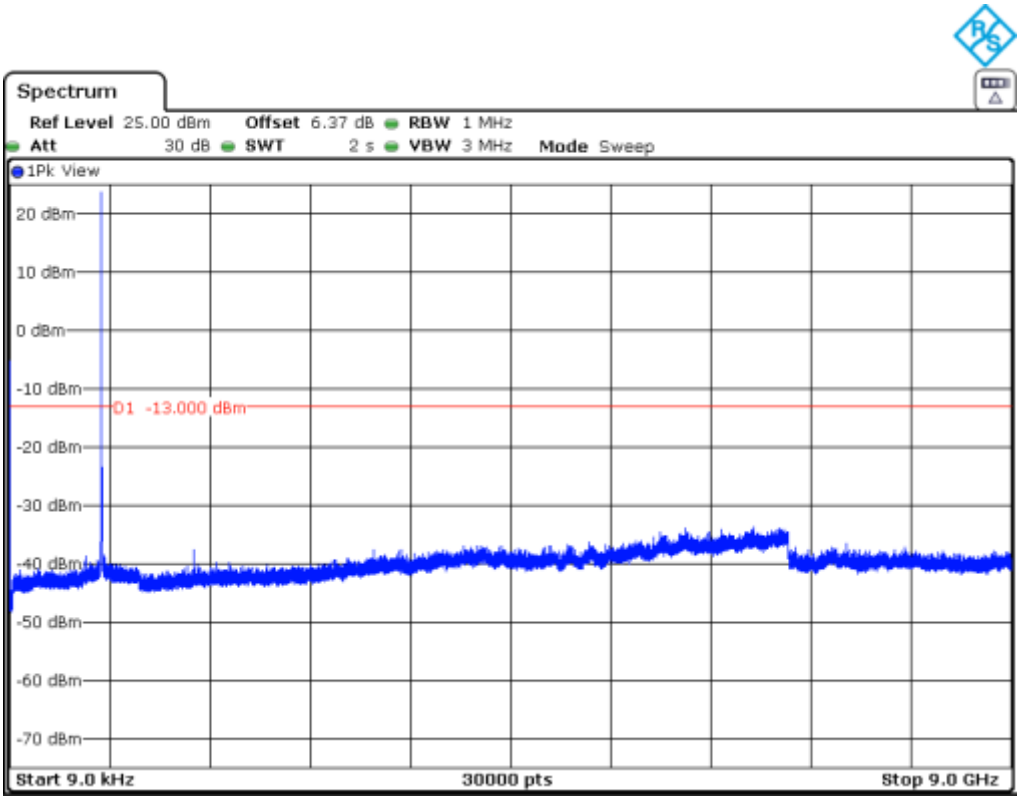
Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE



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

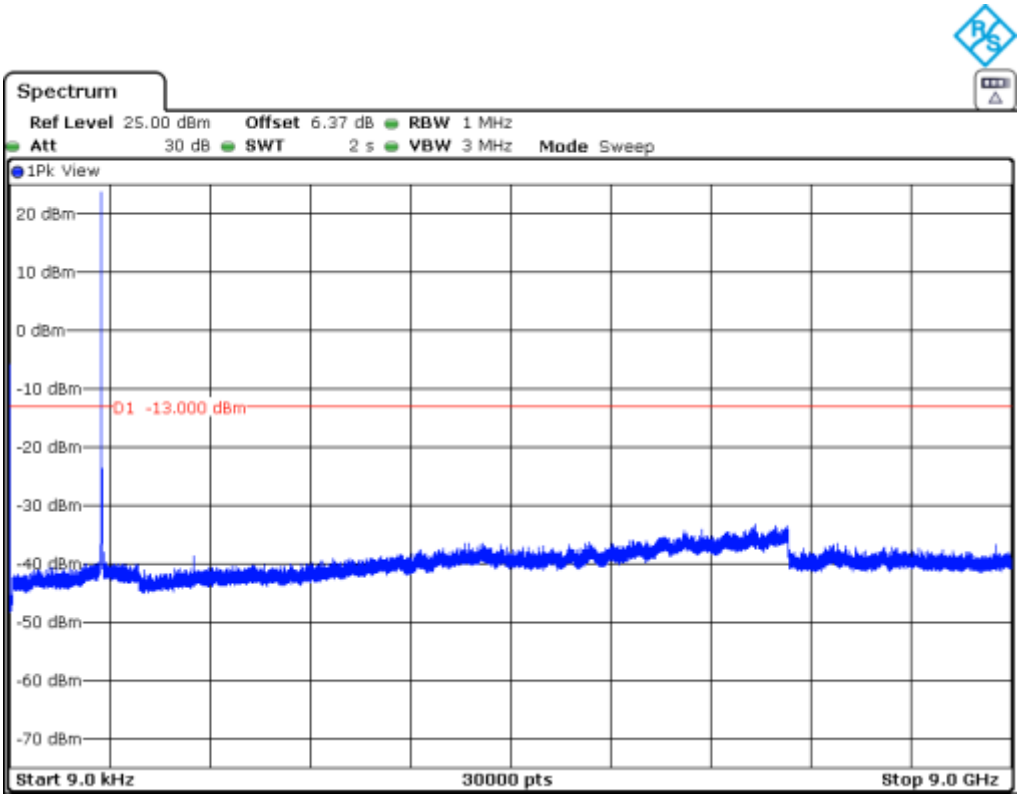
3. CHANNEL: HIGHEST



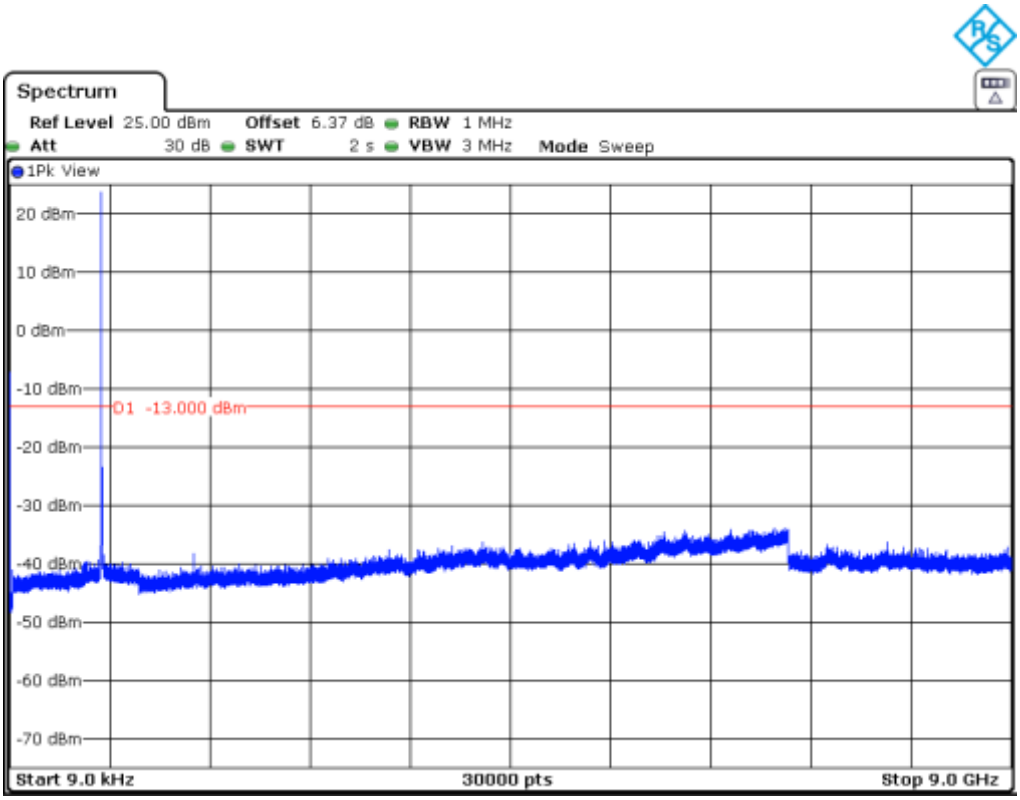
Note: The peak above the limit is the carrier frequency.

Cross-rule channel (824MHz):

NBIoT BAND 26 (Tone 3.75 kHz. π/2 - BPSK MODULATION)



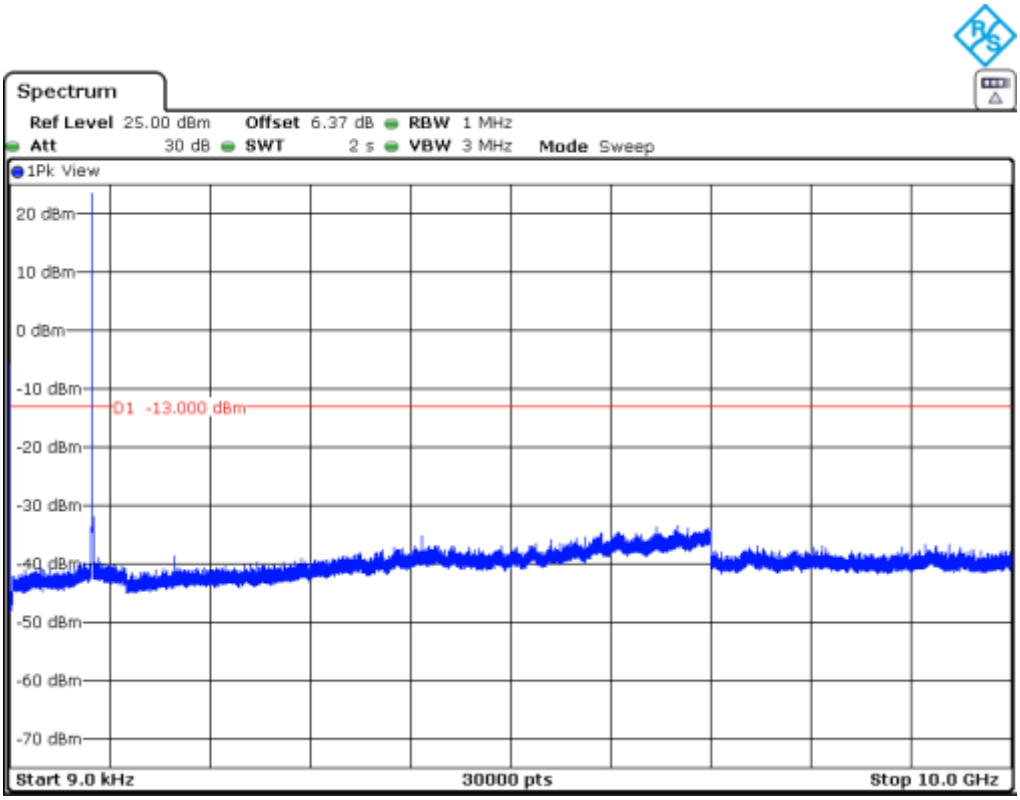
NBIoT BAND 26 (Tone 15 kHz. π/2 - BPSK MODULATION)



824-849MHz Band:

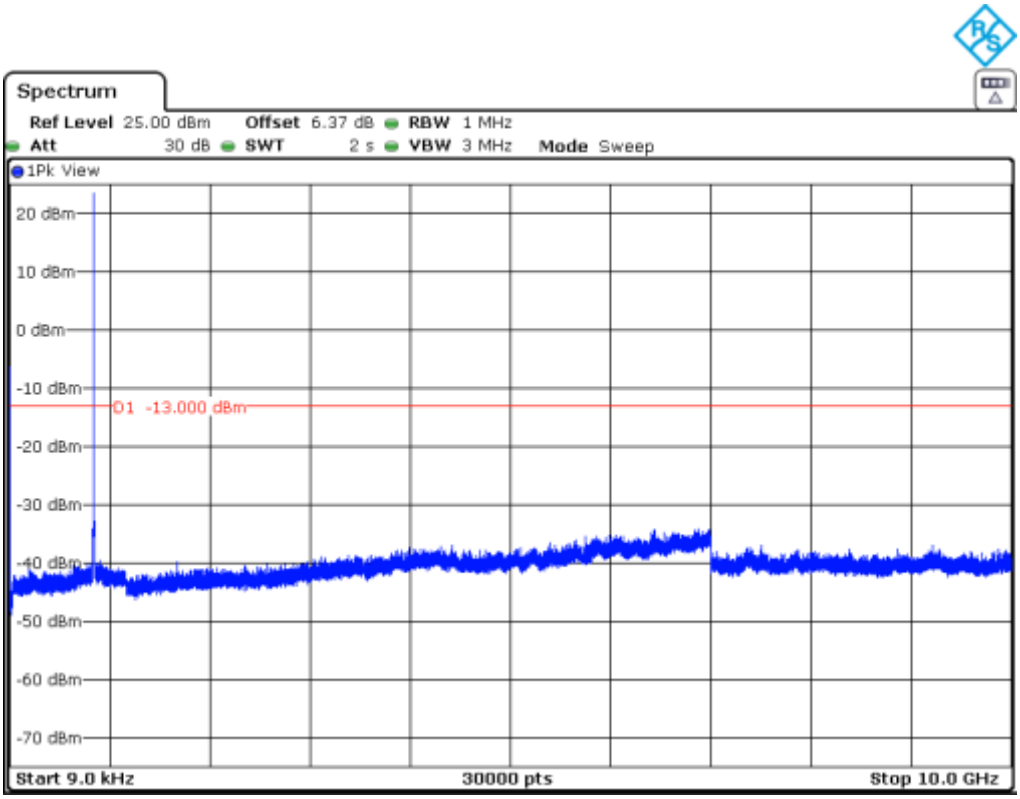
NBIoT BAND 5 (Tone 3.75 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST



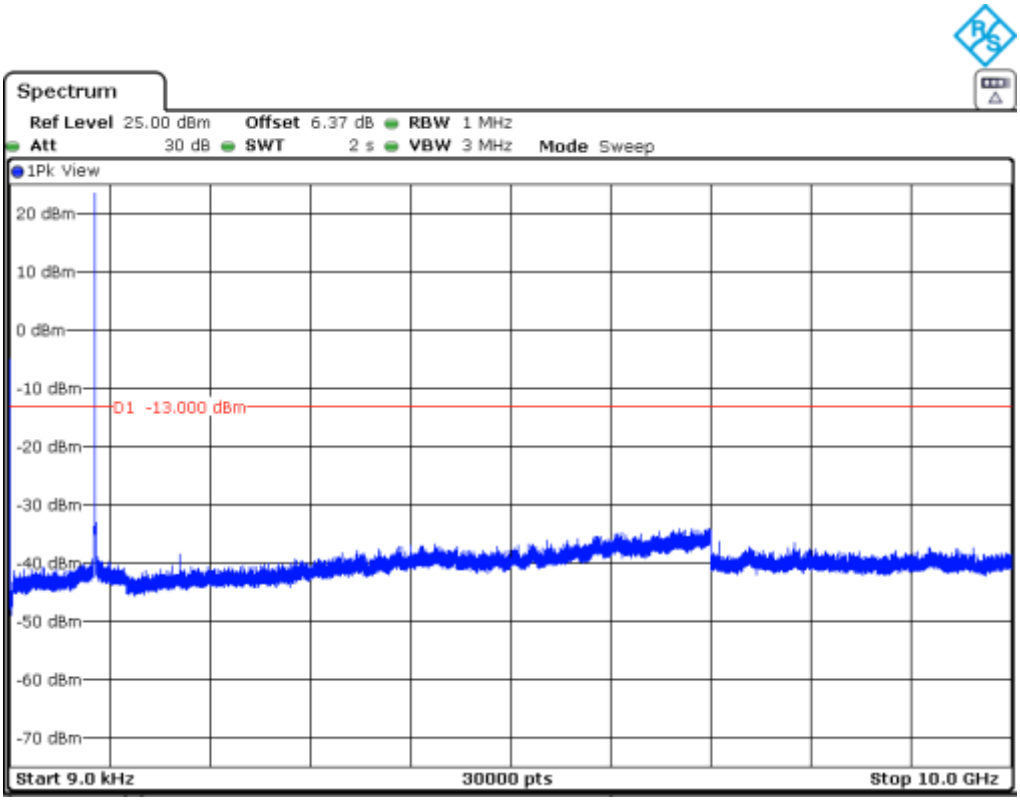
Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE



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

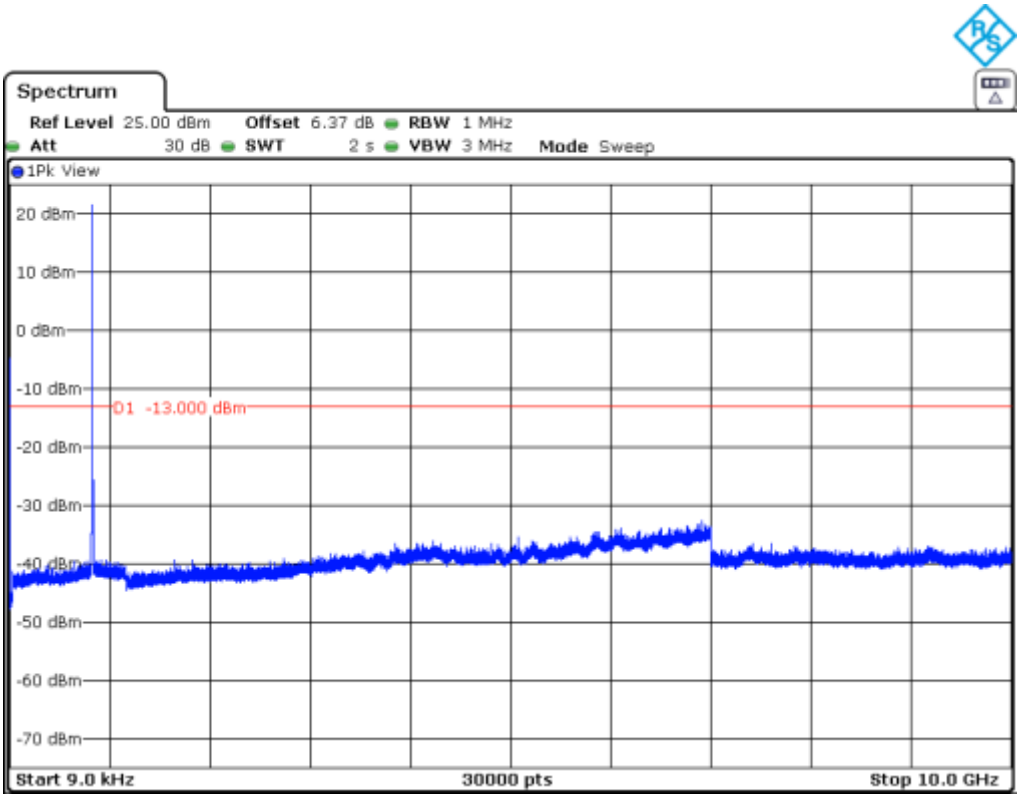
3. CHANNEL: HIGHEST



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

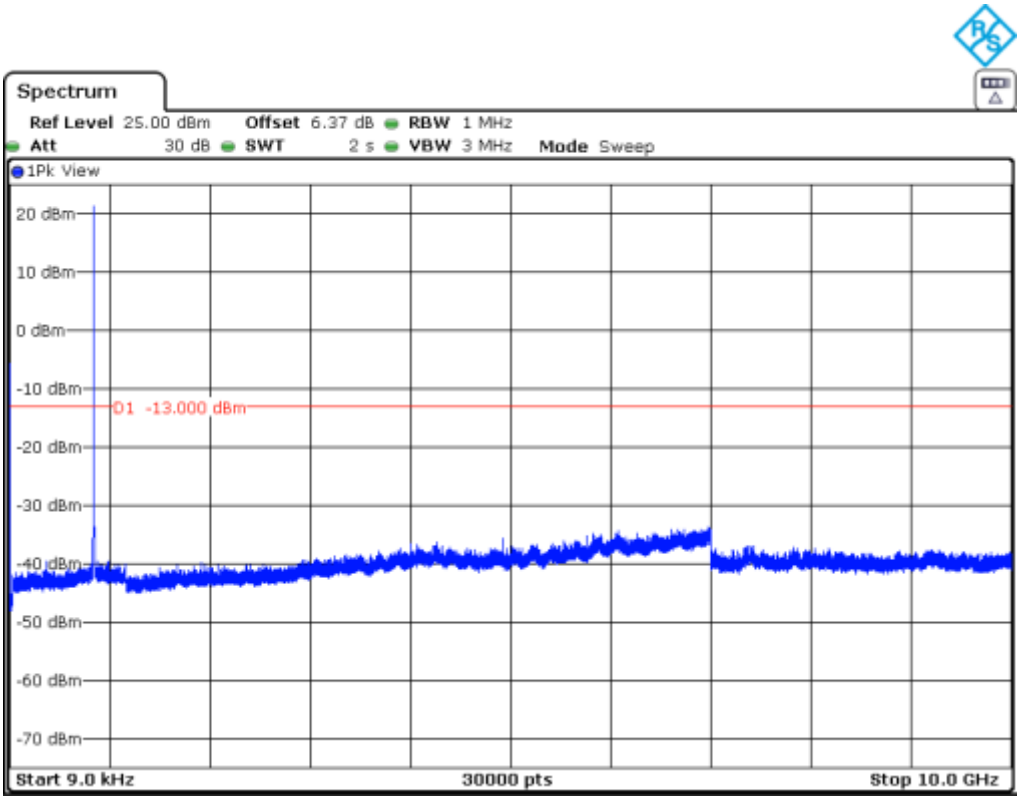
NBIoT BAND 26 (Tone 15 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST



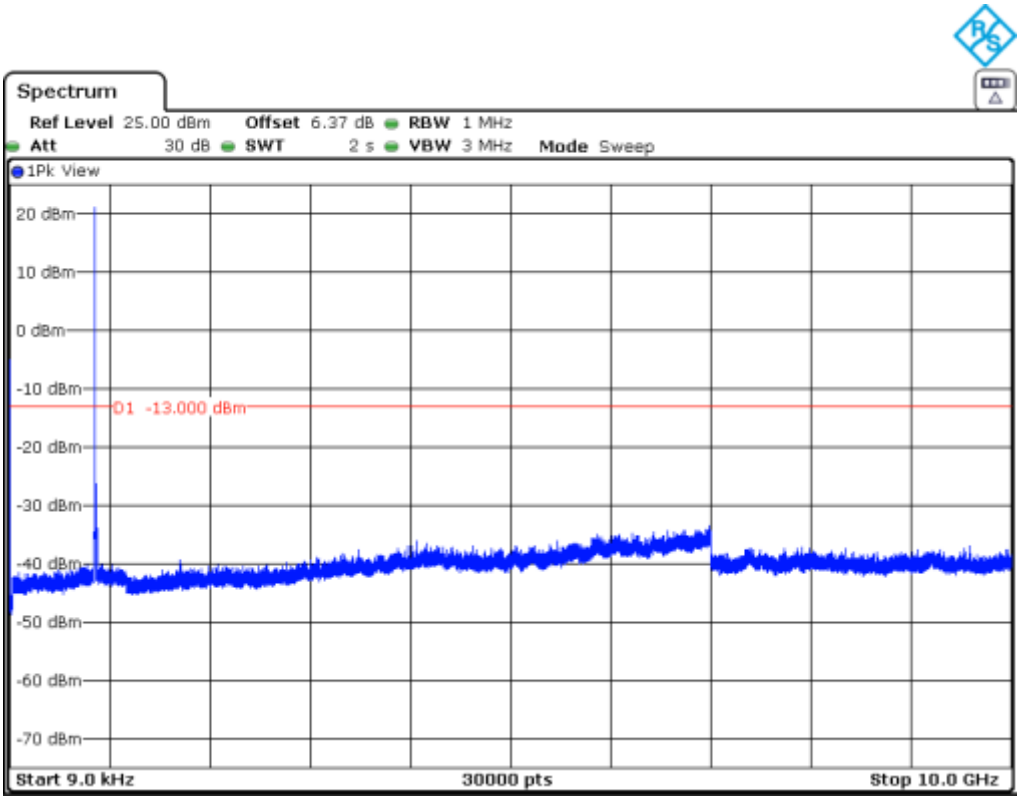
Note: The peak above the limit is the carrier frequency.

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 §22.917
RSS-132. Clause 5.5.

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

FCC §90.691. Emission mask requirements for EA-based systems. Out-of-band emission requirement shall apply only to the “outer” channels included in an EA license and to spectrum adjacent to interior channels used by incumbent licensees. The emission limits are as follows:
(1) For any frequency removed from the EA licensee's frequency block by up to and including 37.5 kHz, the power of any emission shall be attenuated below the transmitter power (P) in watts by at least 116 Log10(f/6.1) decibels or 50 + 10 Log10(P) decibels or 80 decibels, whichever is the lesser attenuation, where f is the frequency removed from the center of the outer channel in the block in kilohertz and where f is greater than 12.5 kHz.
(2) For any frequency removed from the EA licensee's frequency block greater than 37.5 kHz, the power of any emission shall be attenuated below the transmitter power (P) in watts by at least 43 + 10Log10(P) decibels or 80 decibels, whichever is the lesser attenuation, where f is the frequency removed from the center of the outer channel in the block in kilohertz and where f is greater than 37.5 kHz.

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 22, 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.

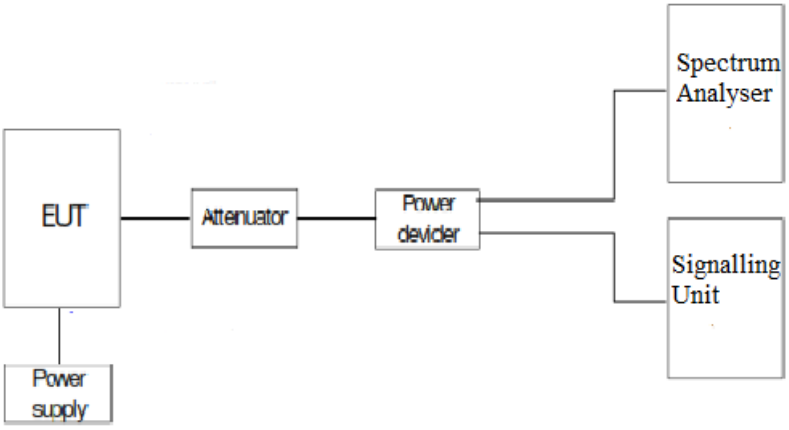
Measurement Limit:

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)

824-849MHz Band:

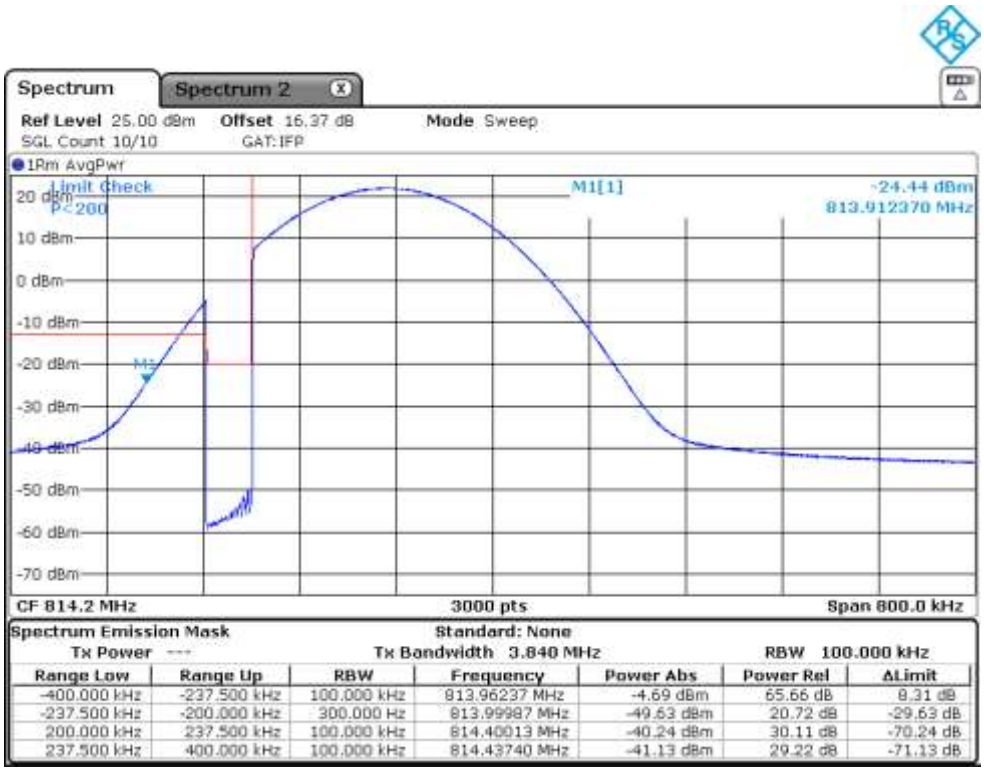
NBIoT	Tone 3.75 kHz. π/4 - QPSK Offset 0 MCS/TBS=3	Tone 15kHz. π/2 - BPSK Offset 0 MCS/TBS=0	12 Tone 15kHz. π/2 - BPSK Offset 0 MCS/TBS=0
Maximum measured level at lowest Block Edge at antenna port (dBm)	-30.28	-31.27	-26.24

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)	-31.96	-39	-25.69

Measurement uncertainty = ±1.57 dB.

814-824 MHz Band "EA MASK".

NBIoT BAND 26 (Tone 3.75 kHz. π/4 - QSK Offset 0)
Lowest Channel:



Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-400.000 kHz	-237.500 kHz	100.000 kHz	813.96237 MHz	-4.69 dBm	65.66 dB	8.31 dB
-237.500 kHz	-200.000 kHz	300.000 Hz	813.99987 MHz	-49.63 dBm	20.72 dB	-29.63 dB
200.000 kHz	237.500 kHz	100.000 kHz	814.40013 MHz	-40.24 dBm	30.11 dB	-70.24 dB
237.500 kHz	400.000 kHz	100.000 kHz	814.43740 MHz	-41.13 dBm	29.22 dB	-71.13 dB

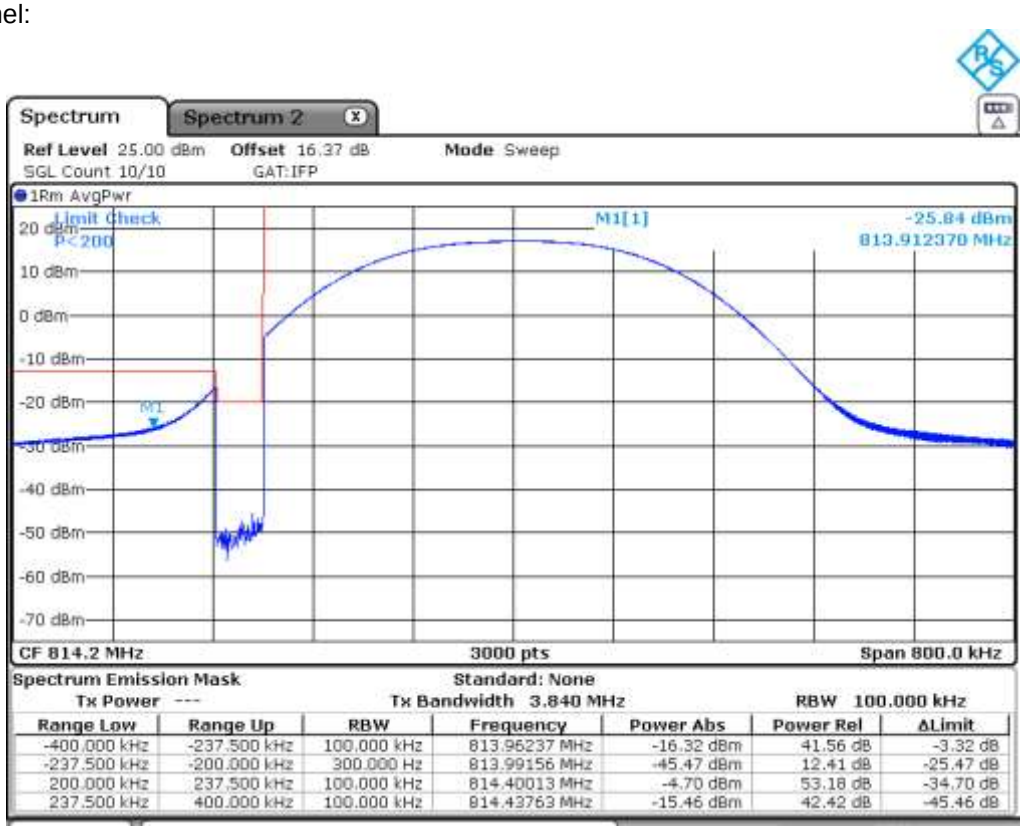
NBIoT BAND 26 (Tone 15 kHz. π/2 - BPSK Offset 0 MODULATION)

Lowest Channel:

Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-400.000 kHz	-237.500 kHz	100.000 kHz	813.96210 MHz	-6.81 dBm	51.07 dB	6.19 dB
-237.500 kHz	-200.000 kHz	300.000 Hz	813.99933 MHz	-47.91 dBm	9.97 dB	-27.91 dB
200.000 kHz	237.500 kHz	100.000 kHz	814.40067 MHz	-41.06 dBm	16.82 dB	-71.06 dB
237.500 kHz	400.000 kHz	100.000 kHz	814.44003 MHz	-41.94 dBm	15.93 dB	-71.94 dB

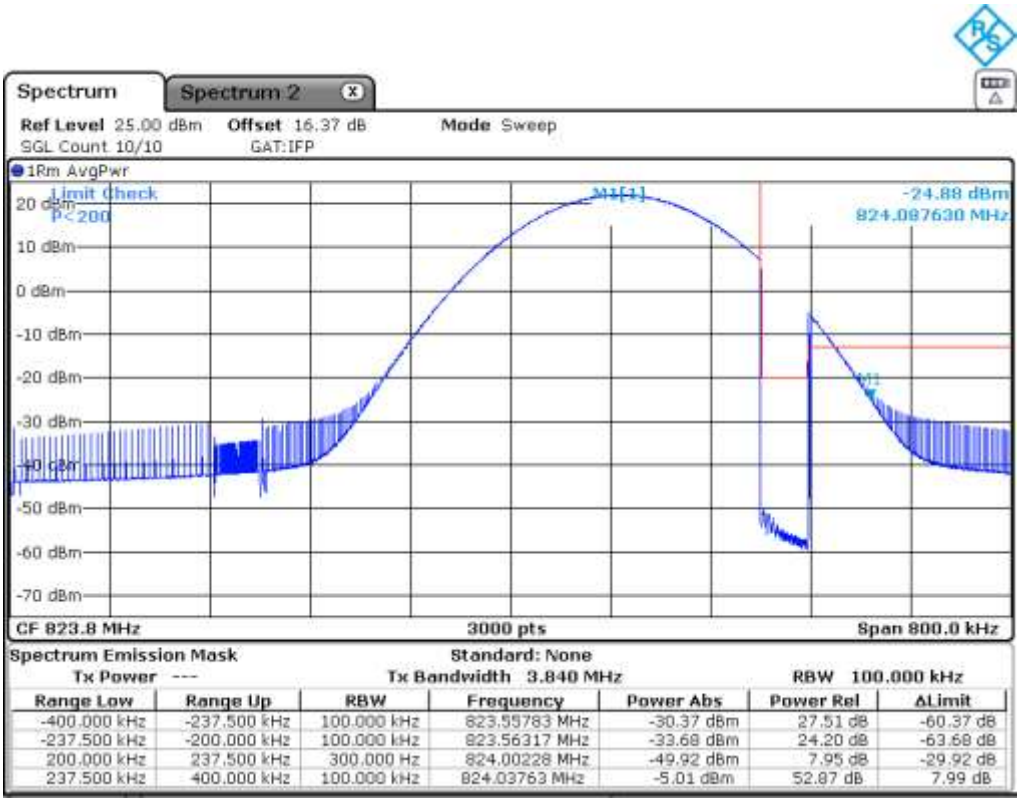
NBIoT BAND 26 (12 Tones 15 kHz. π/4 - QPSK Offset 0 MODULATION)

Lowest Channel:



Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-400.000 kHz	-237.500 kHz	100.000 kHz	813.96237 MHz	-16.32 dBm	41.56 dB	-3.32 dB
-237.500 kHz	-200.000 kHz	300.000 Hz	813.99156 MHz	-45.47 dBm	12.41 dB	-25.47 dB
200.000 kHz	237.500 kHz	100.000 kHz	814.40013 MHz	-4.70 dBm	53.18 dB	-34.70 dB
237.500 kHz	400.000 kHz	100.000 kHz	814.43763 MHz	-15.46 dBm	42.42 dB	-45.46 dB

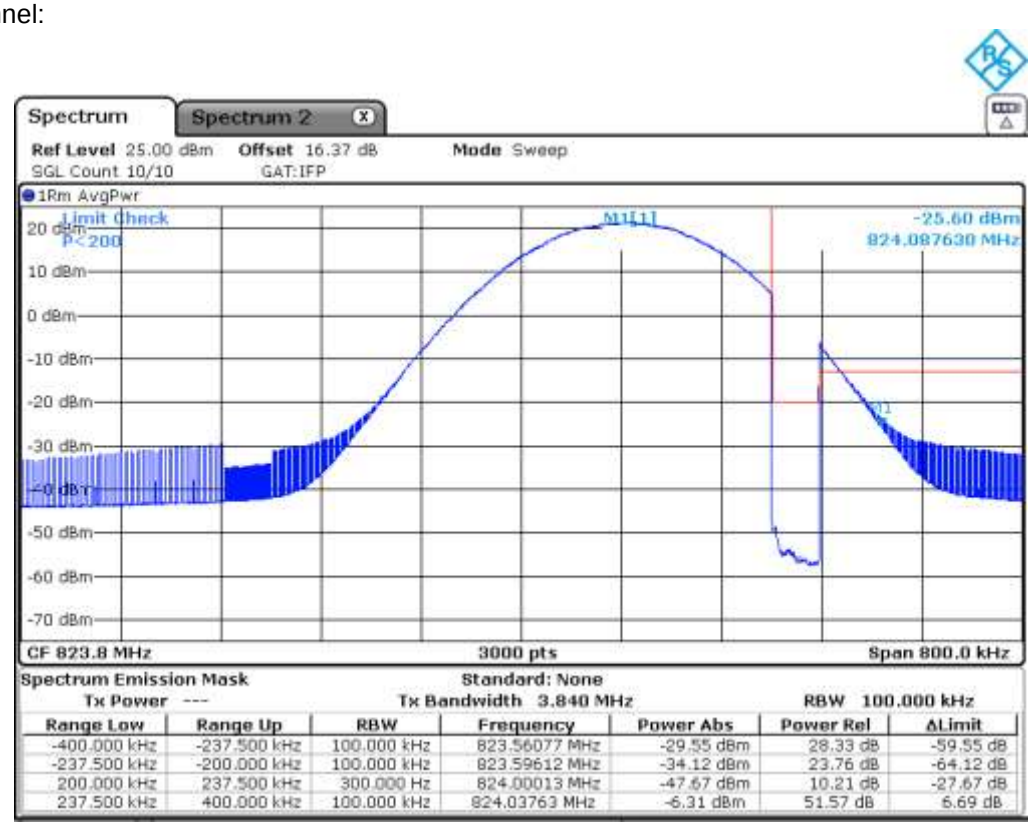
NBIoT BAND 26 (Tone 3.75 kHz. π/2 - BPSK Offset 47 MODULATION)
Highest Channel:



Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-400.000 kHz	-237.500 kHz	100.000 kHz	823.55783 MHz	-30.37 dBm	27.51 dB	-60.37 dB
-237.500 kHz	-200.000 kHz	100.000 kHz	823.56317 MHz	-33.68 dBm	24.20 dB	-63.68 dB
200.000 kHz	237.500 kHz	300.000 Hz	824.00228 MHz	-49.92 dBm	7.95 dB	-29.92 dB
237.500 kHz	400.000 kHz	100.000 kHz	824.03763 MHz	-5.01 dBm	52.87 dB	7.99 dB

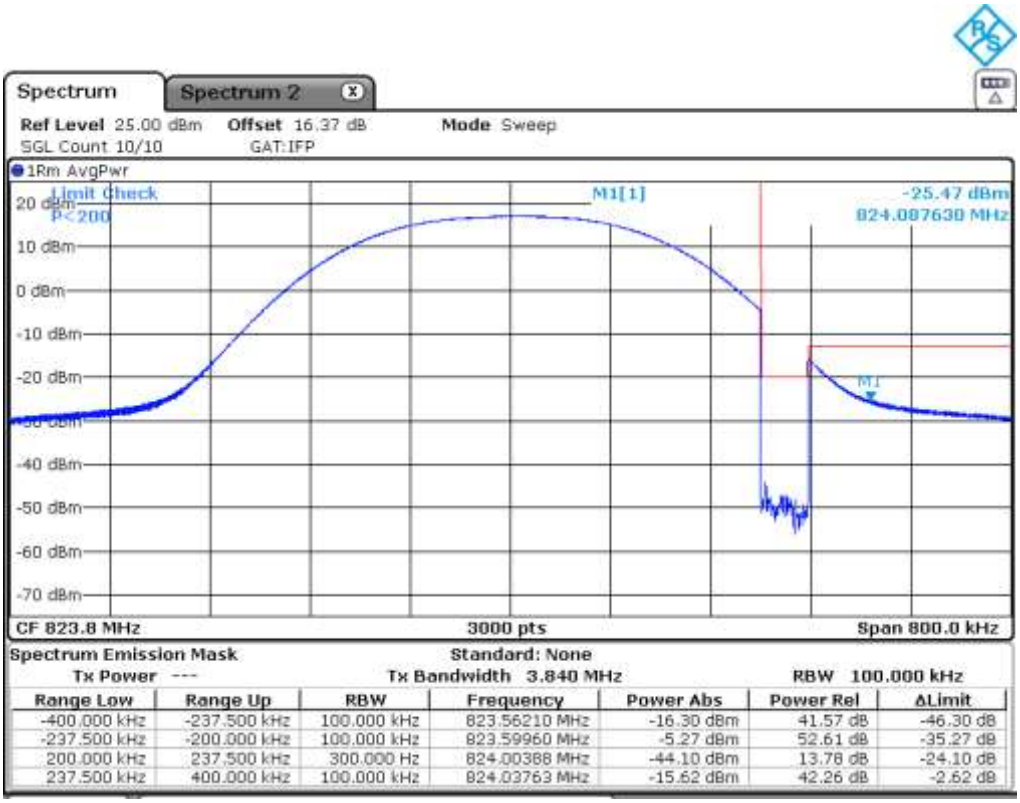
NBIoT BAND 26 (Tone 15 kHz. π/4 - QPSK Offset 11 MODULATION)

Highest Channel:



Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-400.000 kHz	-237.500 kHz	100.000 kHz	823.56077 MHz	-29.55 dBm	28.33 dB	-59.55 dB
-237.500 kHz	-200.000 kHz	100.000 kHz	823.59612 MHz	-34.12 dBm	23.76 dB	-64.12 dB
200.000 kHz	237.500 kHz	300.000 Hz	824.00013 MHz	-47.67 dBm	10.21 dB	-27.67 dB
237.500 kHz	400.000 kHz	100.000 kHz	824.03763 MHz	-6.31 dBm	51.57 dB	6.69 dB

NBIoT BAND 26 (12 Tones 15 kHz. π/4 - QPSK Offset 0 MODULATION)
Highest Channel:



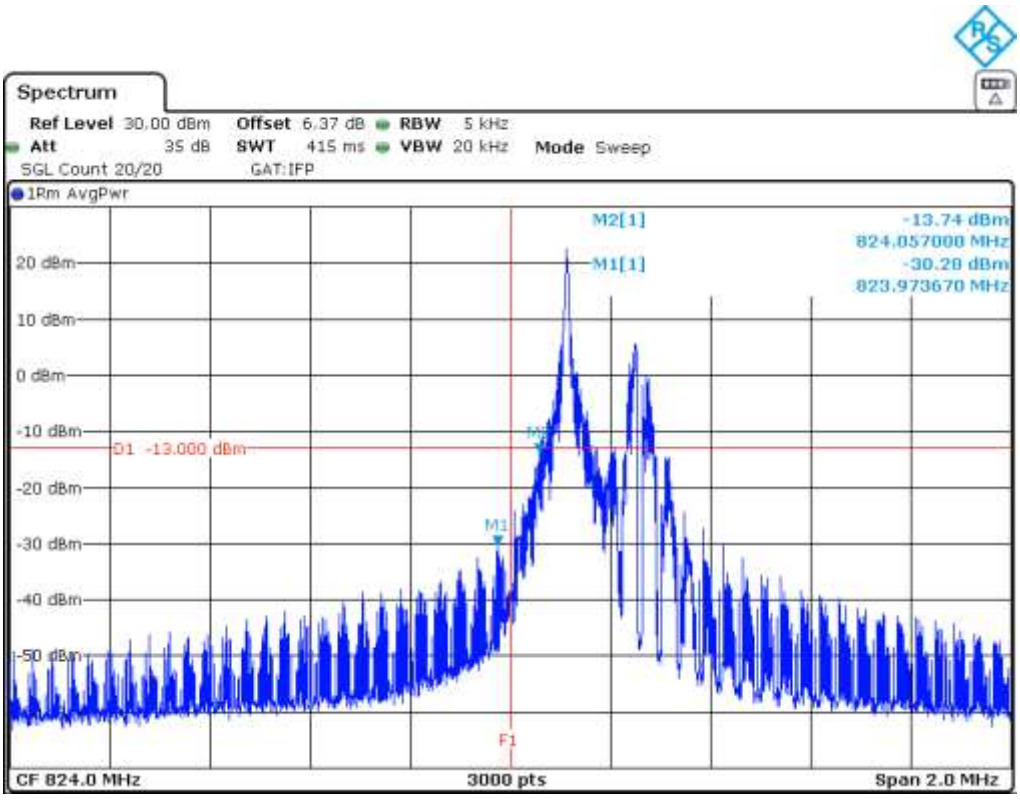
Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-400.000 kHz	-237.500 kHz	100.000 kHz	823.56210 MHz	-16.30 dBm	41.57 dB	-46.30 dB
-237.500 kHz	-200.000 kHz	100.000 kHz	823.59960 MHz	-5.27 dBm	52.61 dB	-35.27 dB
200.000 kHz	237.500 kHz	300.000 Hz	824.00388 MHz	-44.10 dBm	13.78 dB	-24.10 dB
237.500 kHz	400.000 kHz	100.000 kHz	824.03763 MHz	-15.62 dBm	42.26 dB	-2.62 dB

Verdict: PASS

824-849 MHz:

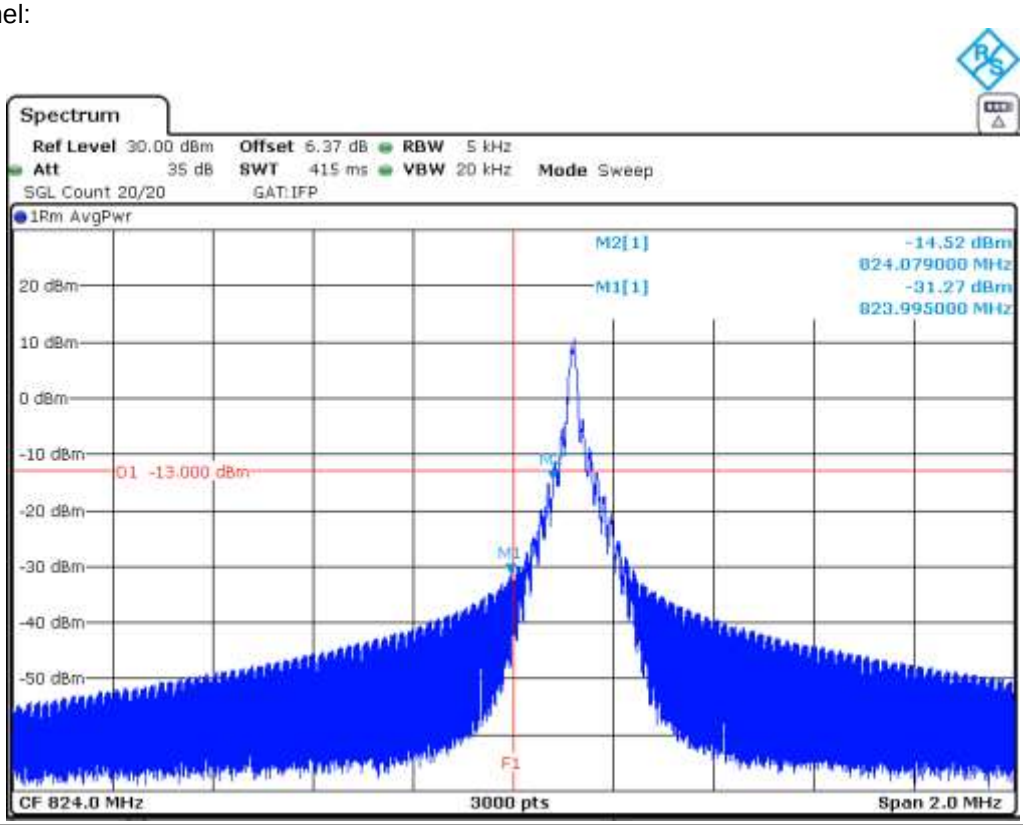
NBIoT BAND 5 (Tone 3.75 kHz. π/2 - BPSK Offset 0 MODULATION)

Lowest Channel:



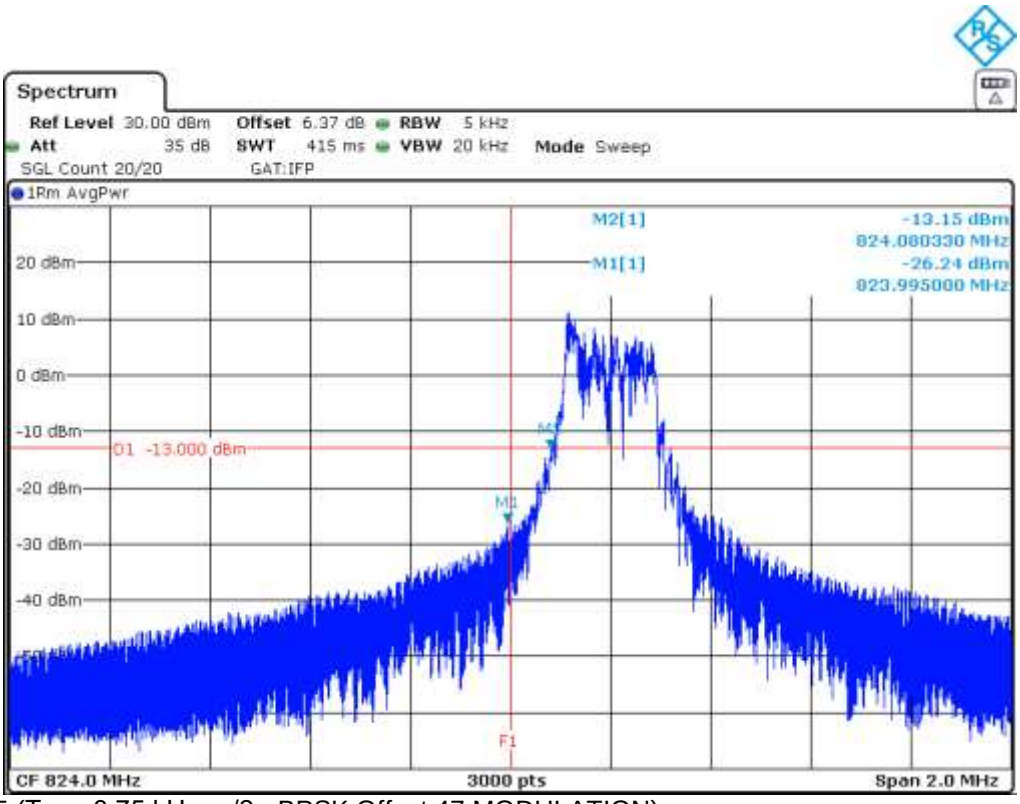
NBIoT BAND 5 (Tone 15 kHz. π/4 - QPSK Offset 0 MODULATION)

Lowest Channel:



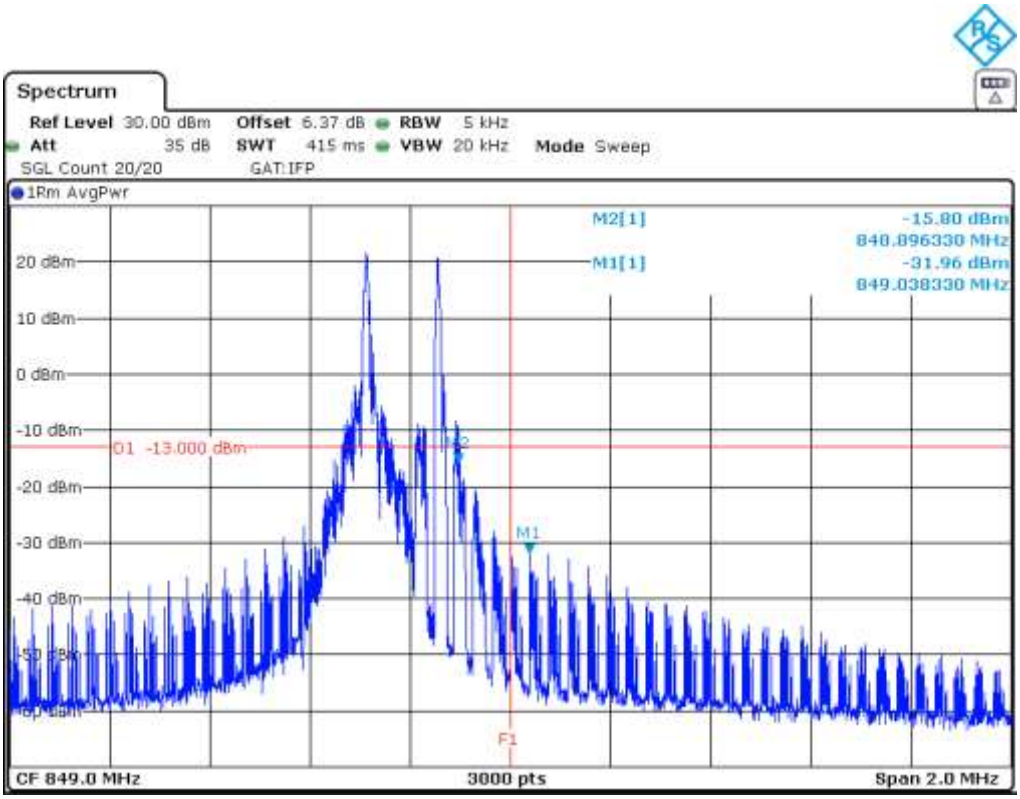
NBIoT BAND 5 (12 Tones 15 kHz. π/4 - QPSK Offset 0 MODULATION)

Lowest Channel:



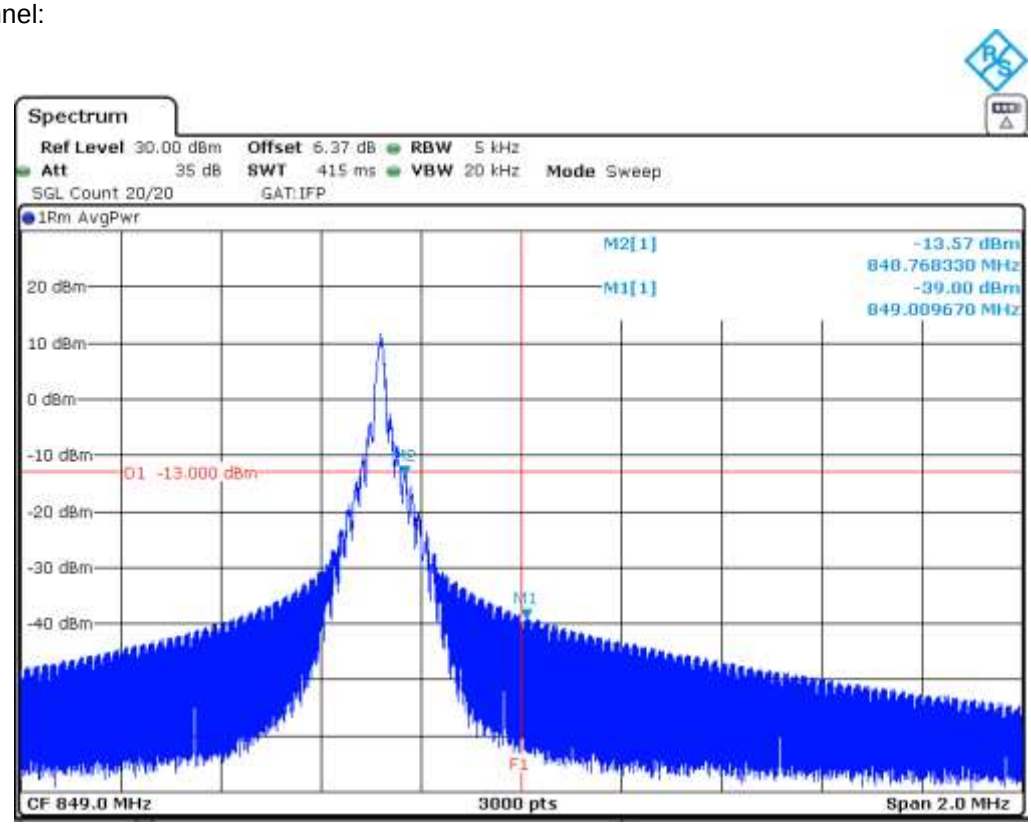
NBIoT BAND 5 (Tone 3.75 kHz. π/2 - BPSK Offset 47 MODULATION)

Highest Channel:



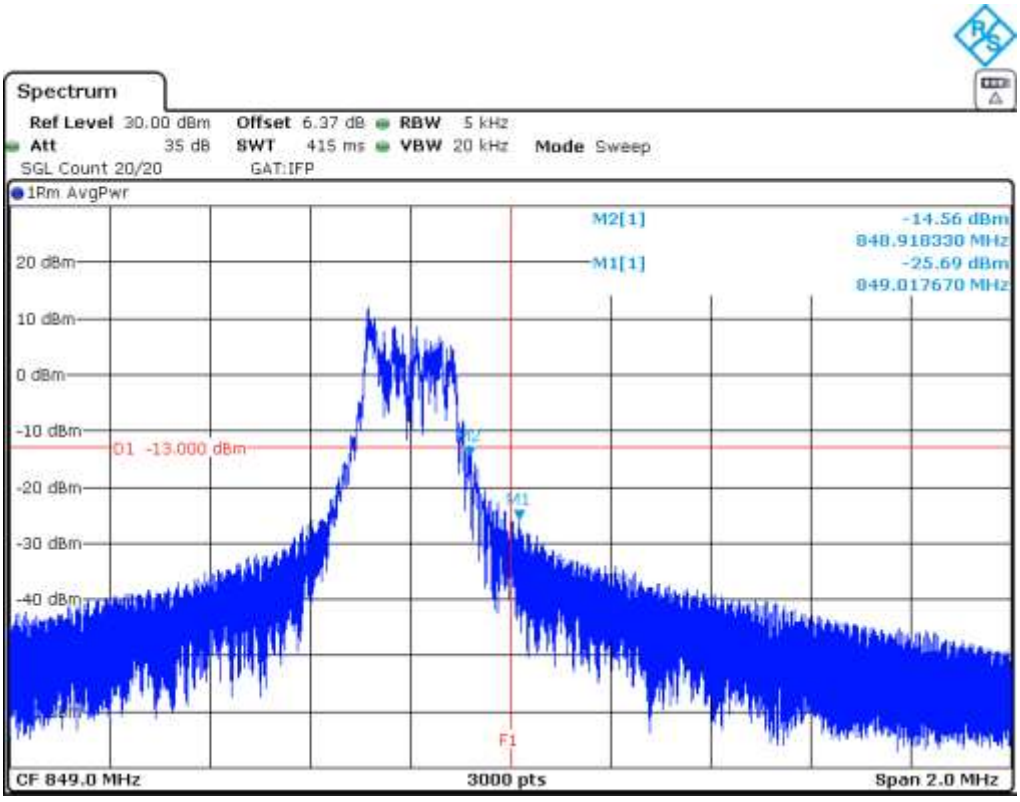
NBIoT BAND 5 (Tone 15 kHz. π/4 - QPSK Offset 11 MODULATION)

Highest Channel:



NBIoT BAND 5 (12 Tones 15 kHz. π/4 - QPSK Offset 0 MODULATION)

Highest Channel:



Radiated emissions

SPECIFICATION

FCC § 22.917

RSS-132. Clause 5.5.

FCC §2.1051, §90.691

Emission mask requirements for EA-based systems.

For any frequency removed from the EA licensee's frequency block greater than 37.5 kHz, the power of any emission shall be attenuated below the transmitter power (P) in watts by at least 43 + 10Log10(P) decibels or 80 decibels, whichever is the lesser attenuation, where f is the frequency removed from the center of the outer channel in the block in kilohertz and where f is greater than 37.5 kHz.

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 1 meter high 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

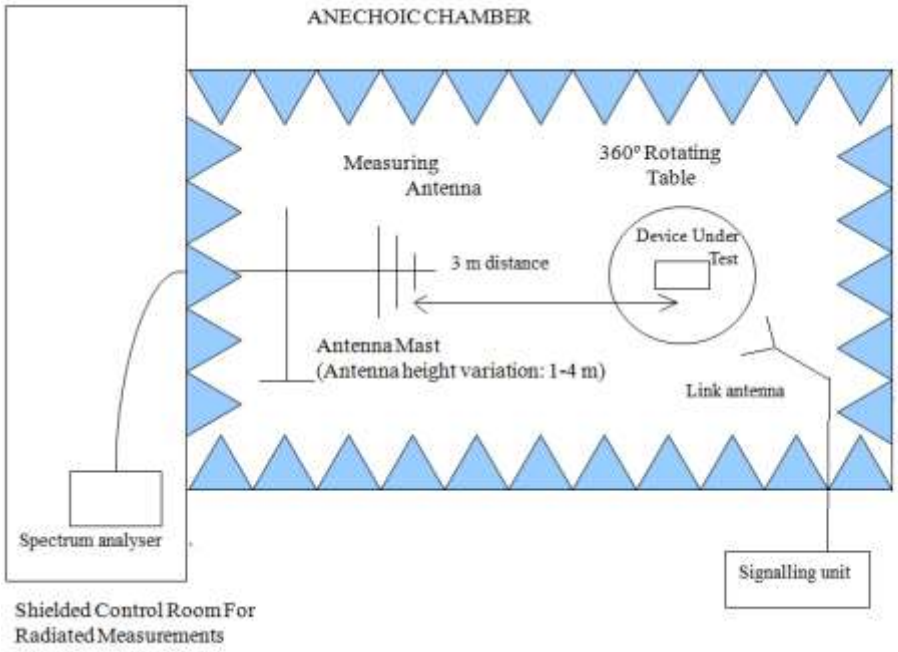
Measurement Limit:

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:

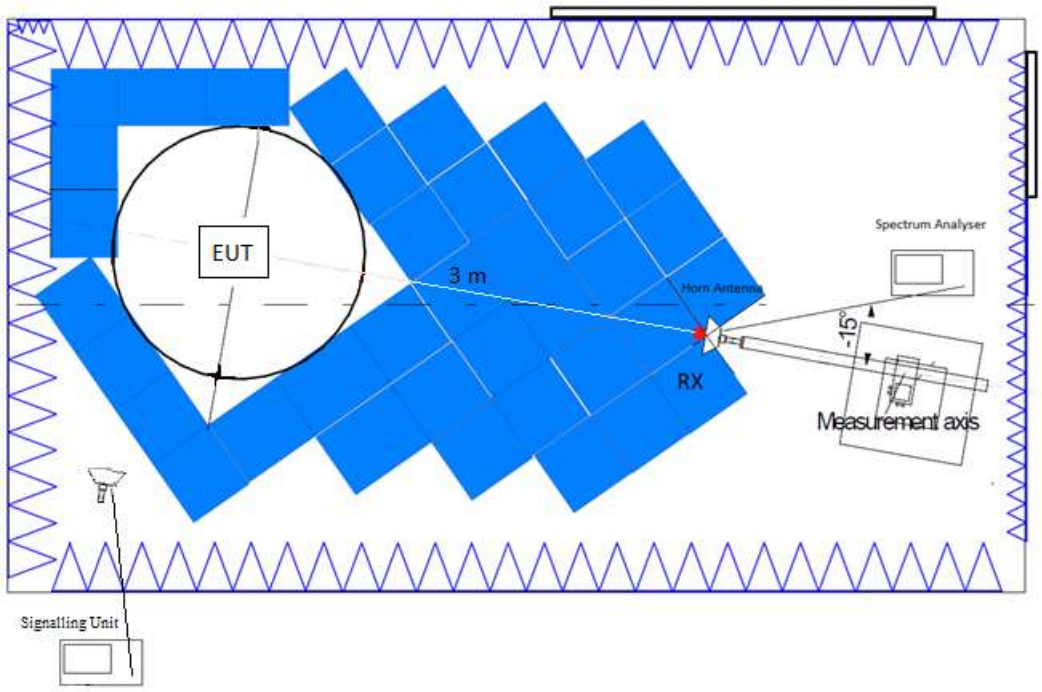
Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = - 13 dBm

TEST SETUP

Radiated measurements below 1 GHz.



Radiated measurements above 1 GHz.



RESULTS

814-824MHz Band:

Preliminary measurements determined that 1 tone of 3.75kHz (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-8.5 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-8.5 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-8.5 GHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

Measurement uncertainty (dB)	<±4.65 for f < 1GHz <±4.98 for f ≥ 1 GHz up to 10 GHz

Verdict: PASS

824-849MHz Band:

Preliminary measurements determined that 1 tones of 3.75kHz (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-8.5 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-8.5 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-8.5 GHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

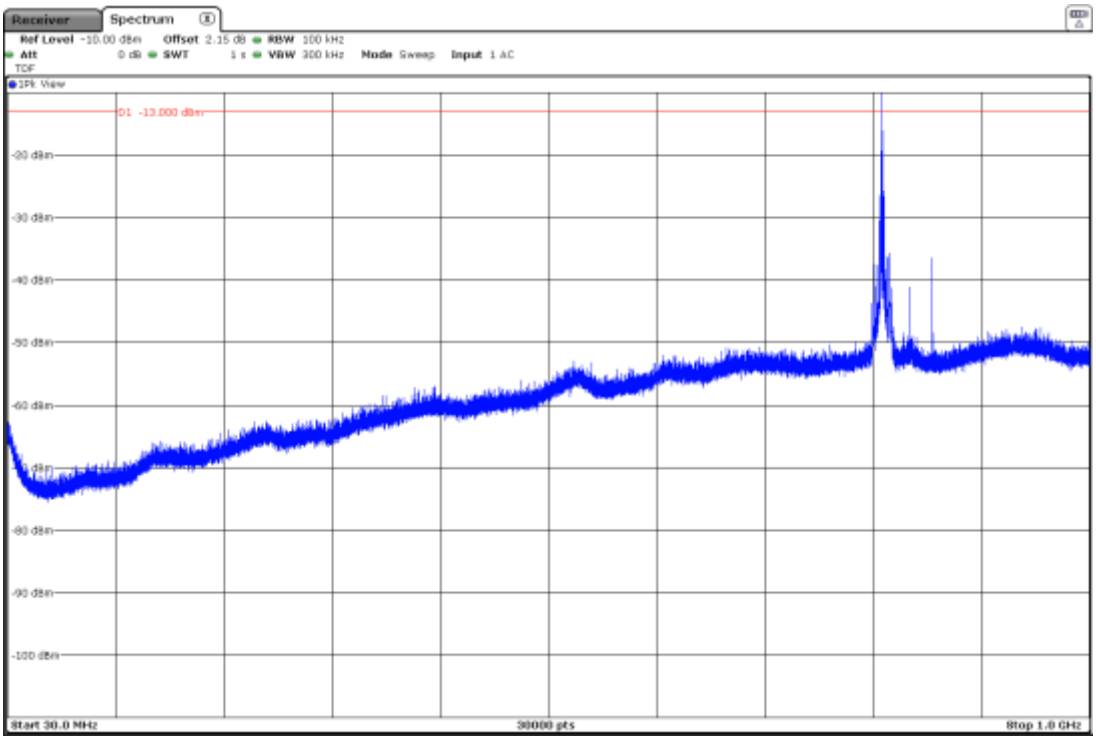
Measurement uncertainty (dB)	<±4.65 for f < 1GHz <±4.98 for f ≥ 1 GHz up to 10 GHz

Verdict: PASS

814-824MHz Band:

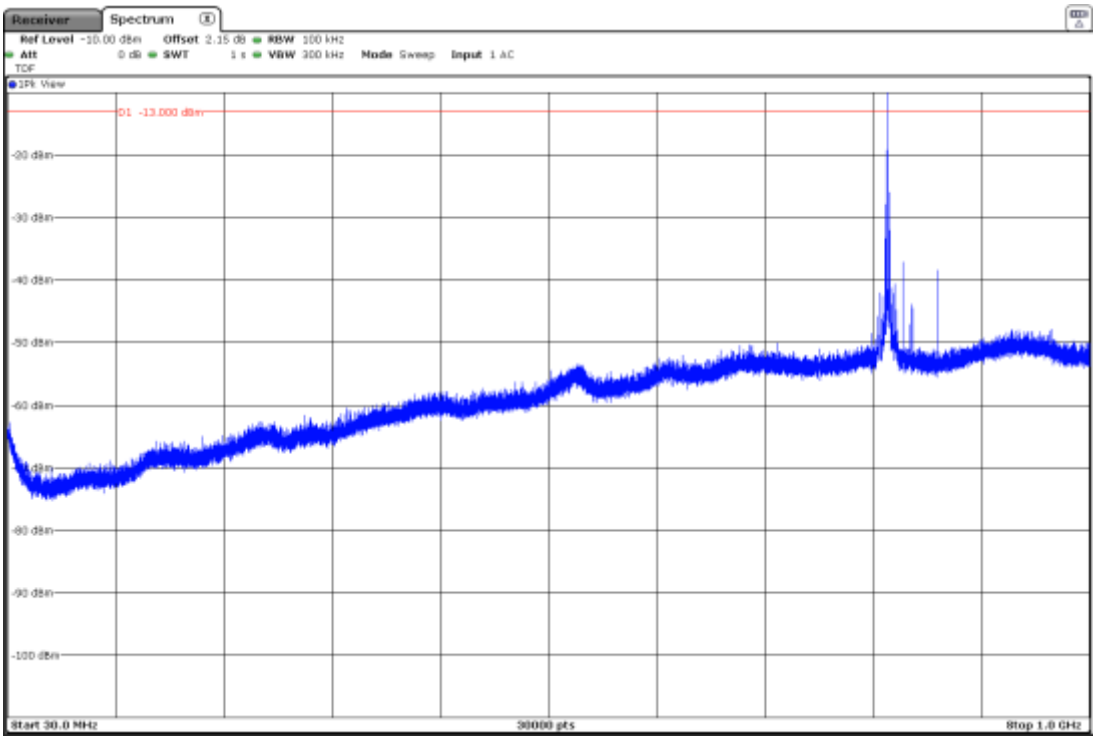
FREQUENCY RANGE 30 MHz-1000 MHz.

CHANNEL: LOWEST



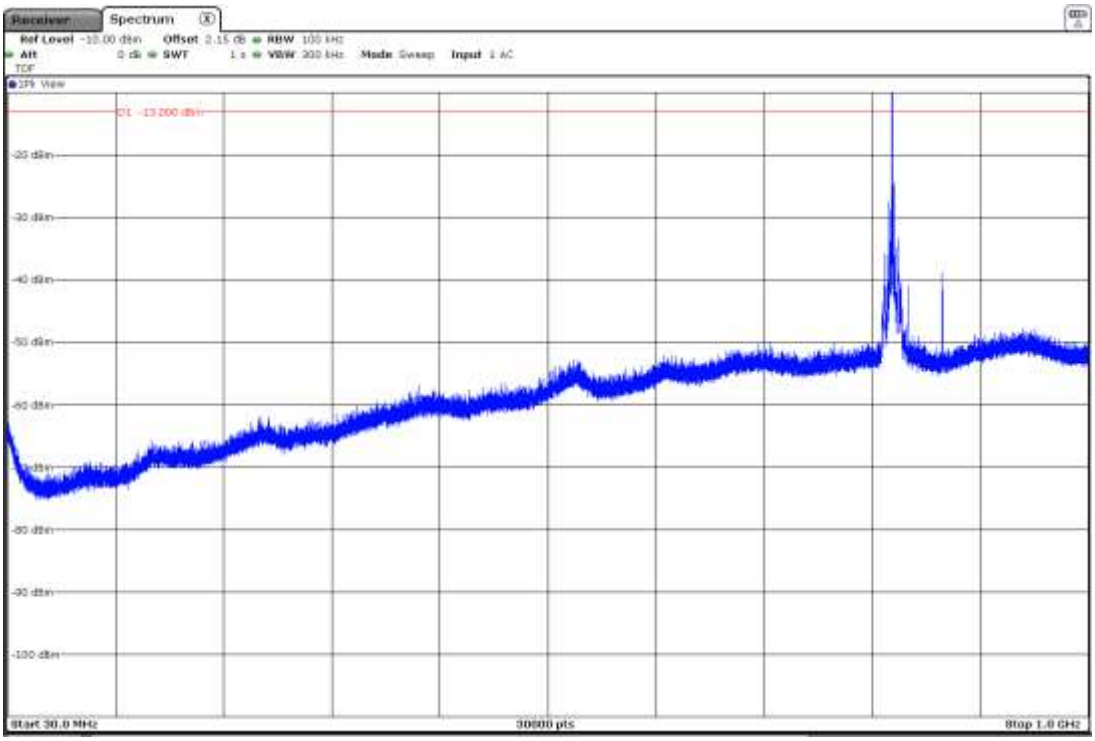
Note: The peak above the limit is the carrier frequency. The peak at 859MHz corresponds to the downlink signal

CHANNEL: MIDDLE



Note: The peak above the limit is the carrier frequency. The peak at 864MHz corresponds to the downlink signal

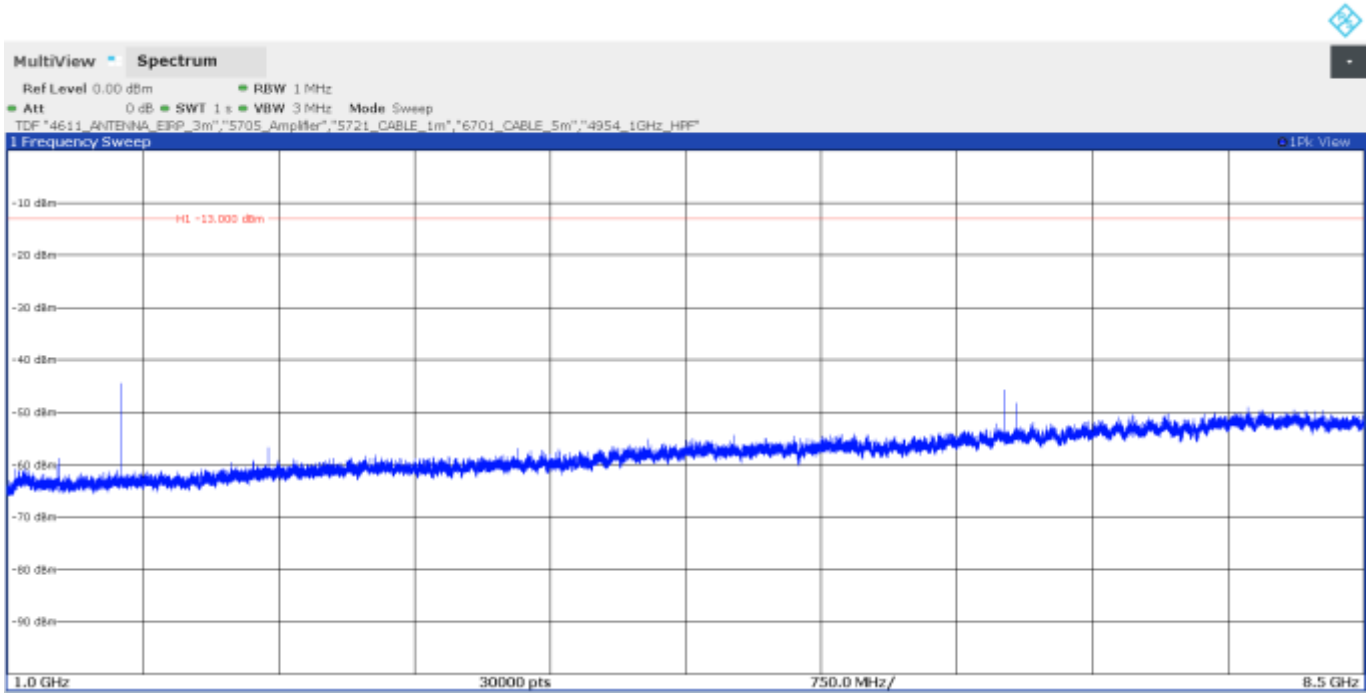
CHANNEL: HIGHEST



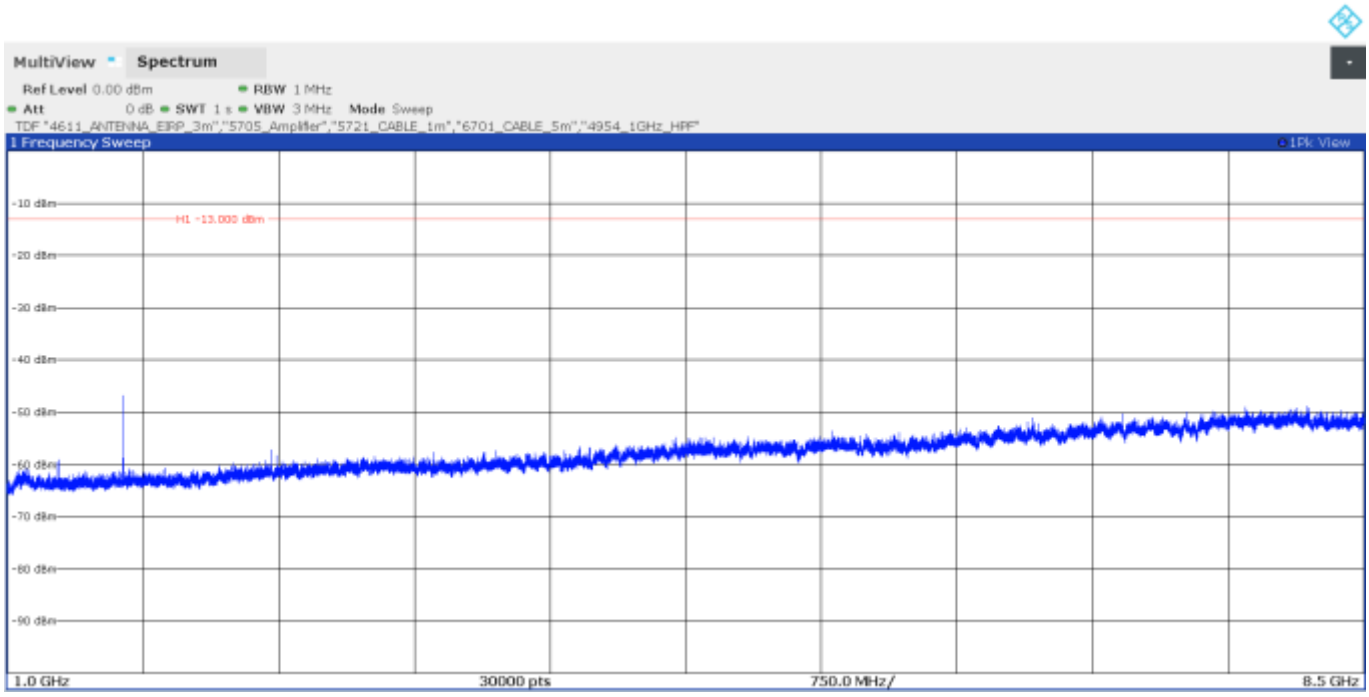
Note: The peak above the limit is the carrier frequency. The peak at 869MHz corresponds to the downlink signal

FREQUENCY RANGE 1 GHz to 8.5 GHz.

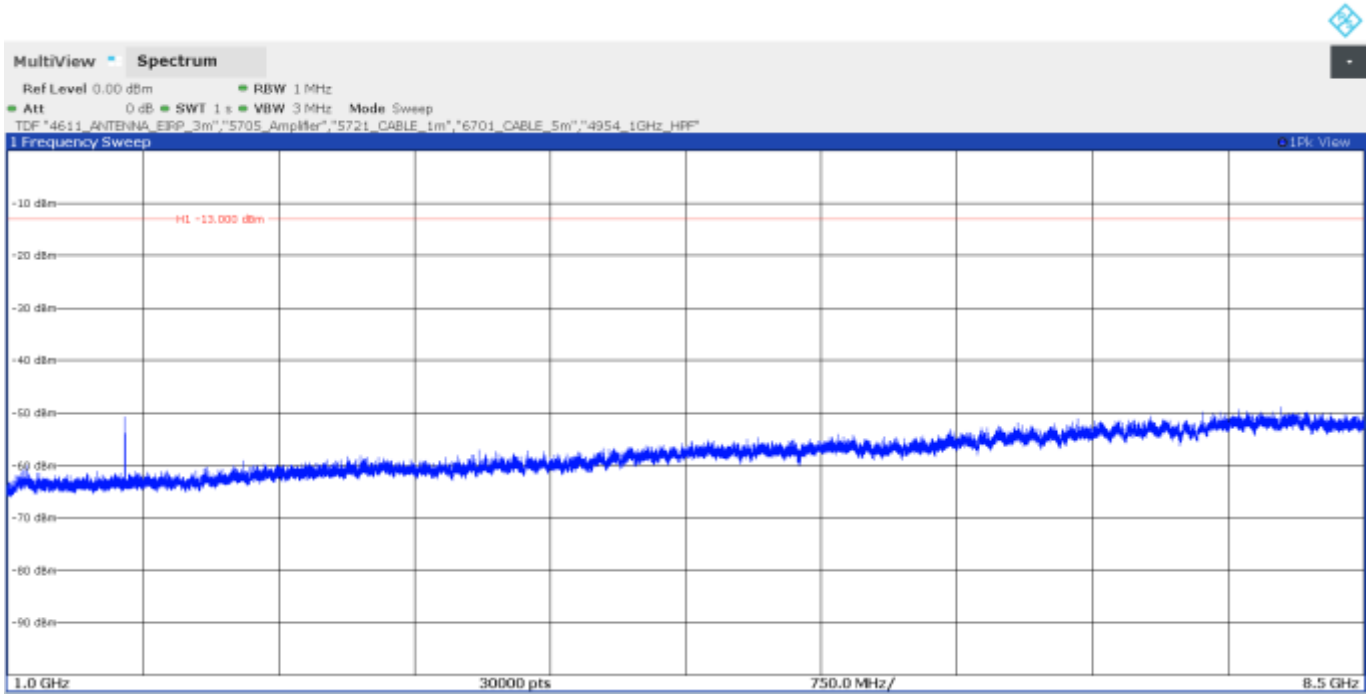
CHANNEL: LOWEST



CHANNEL: MIDDLE



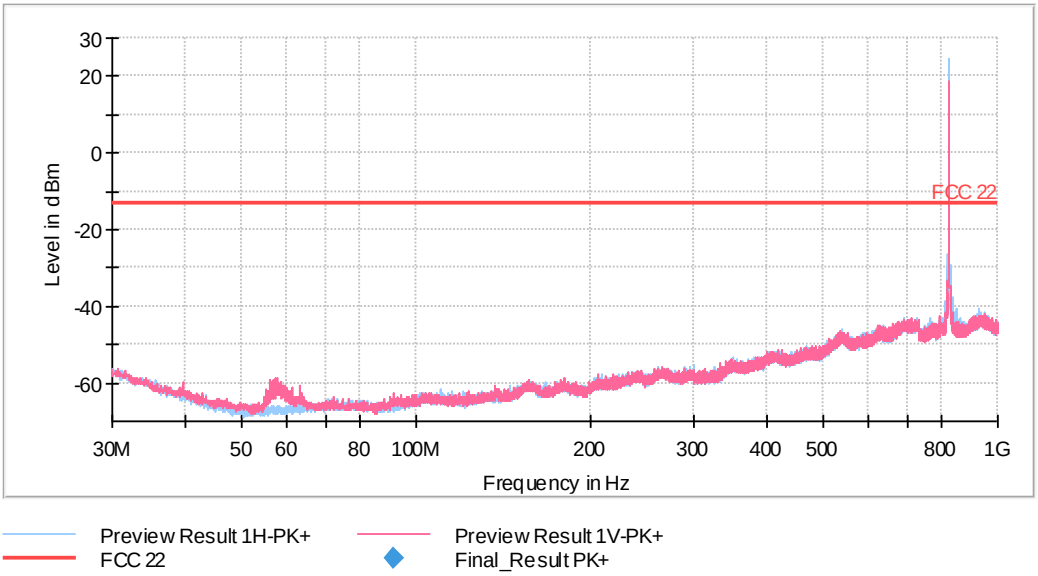
CHANNEL: HIGHEST



824-849MHz Band:

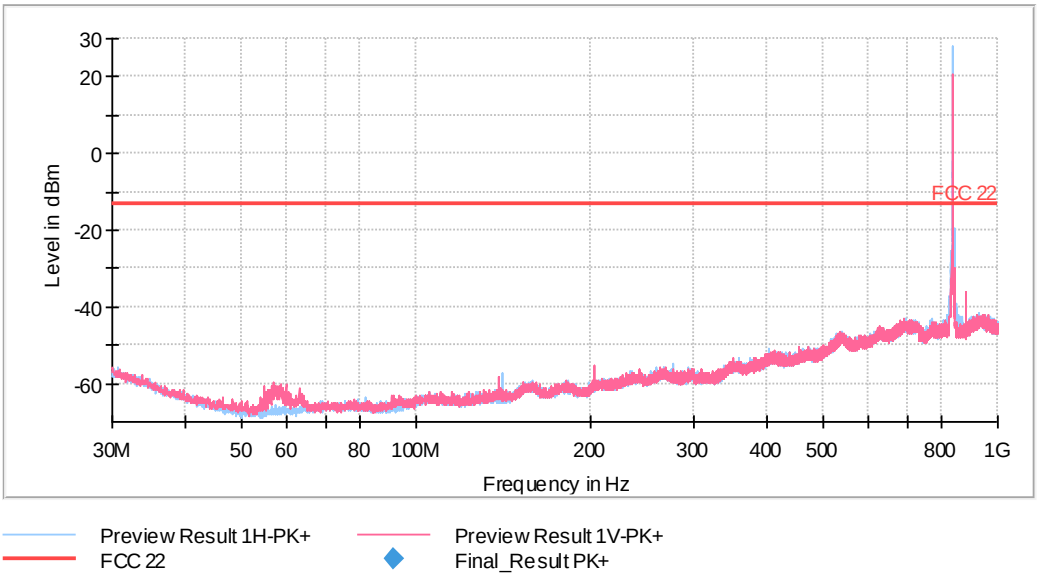
FREQUENCY RANGE 30 MHz-1000 MHz.

CHANNEL: LOWEST



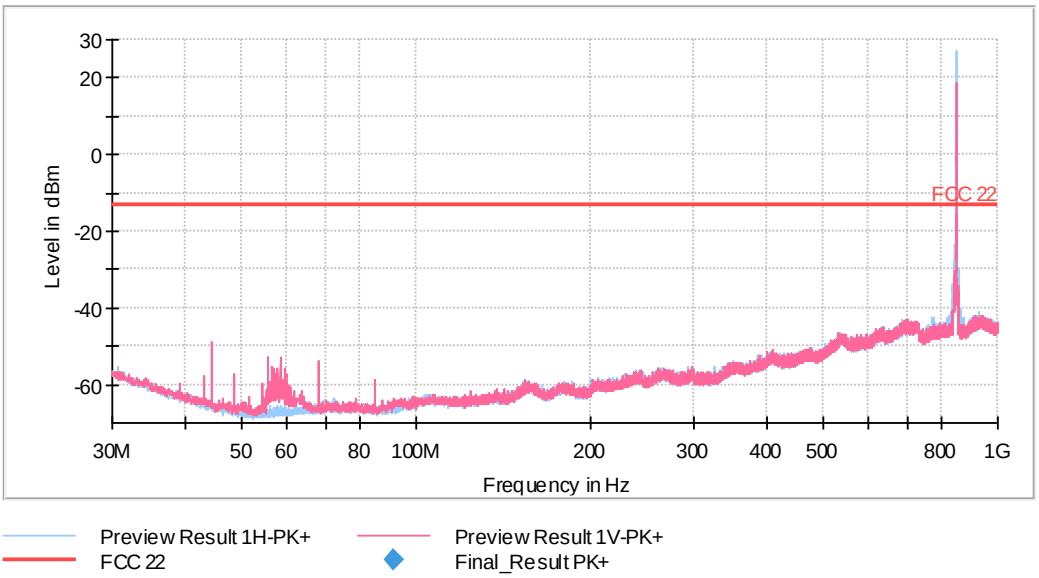
Note: The peak above the limit is the carrier frequency.

CHANNEL: MIDDLE



Note: The peak above the limit is the carrier frequency. The peak at 882MHz corresponds to the downlink signal

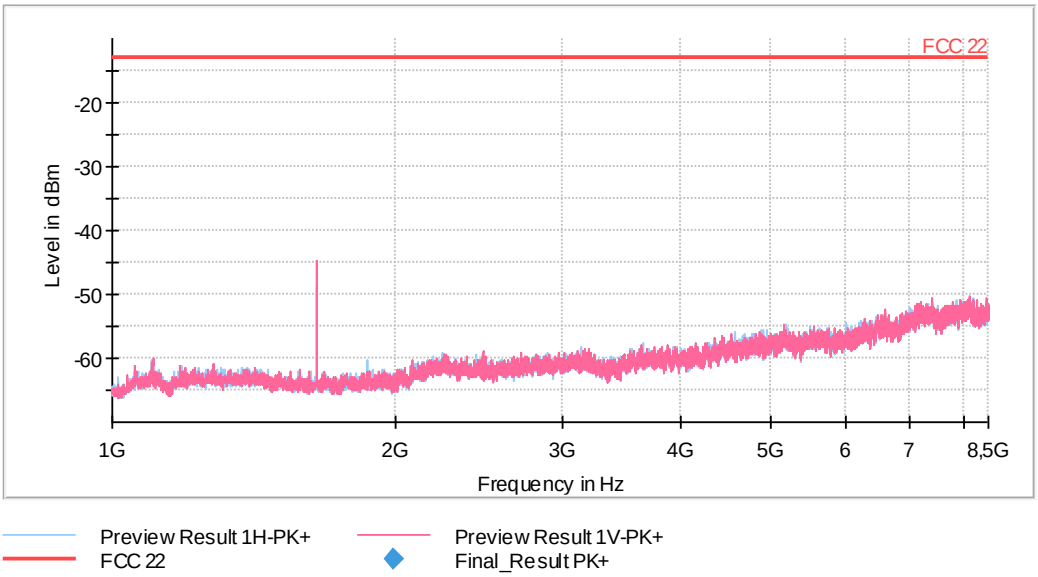
CHANNEL: HIGHEST



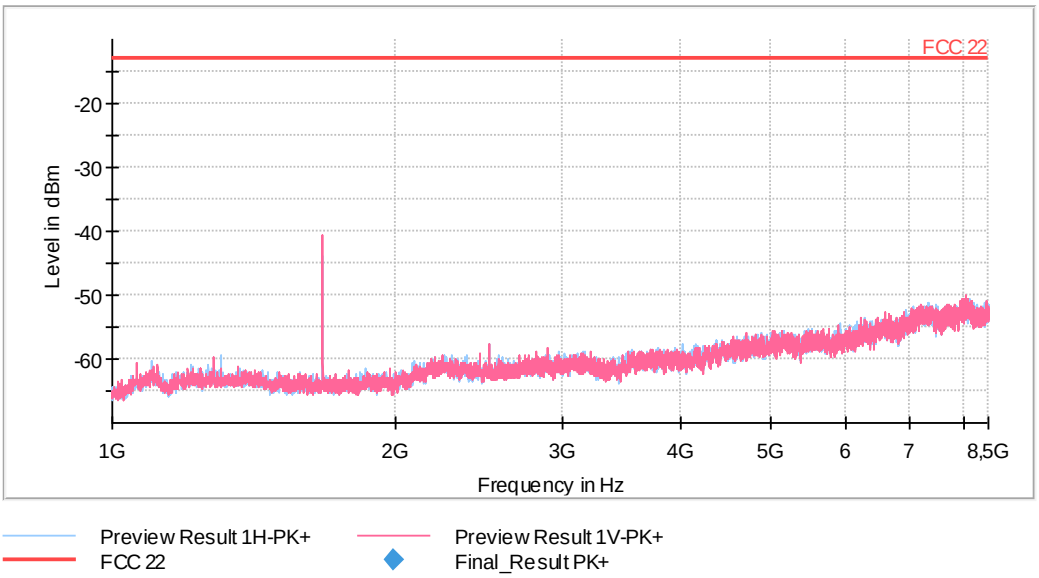
Note: The peak above the limit is the carrier frequency.

FREQUENCY RANGE 1 GHz to 8.5 GHz.

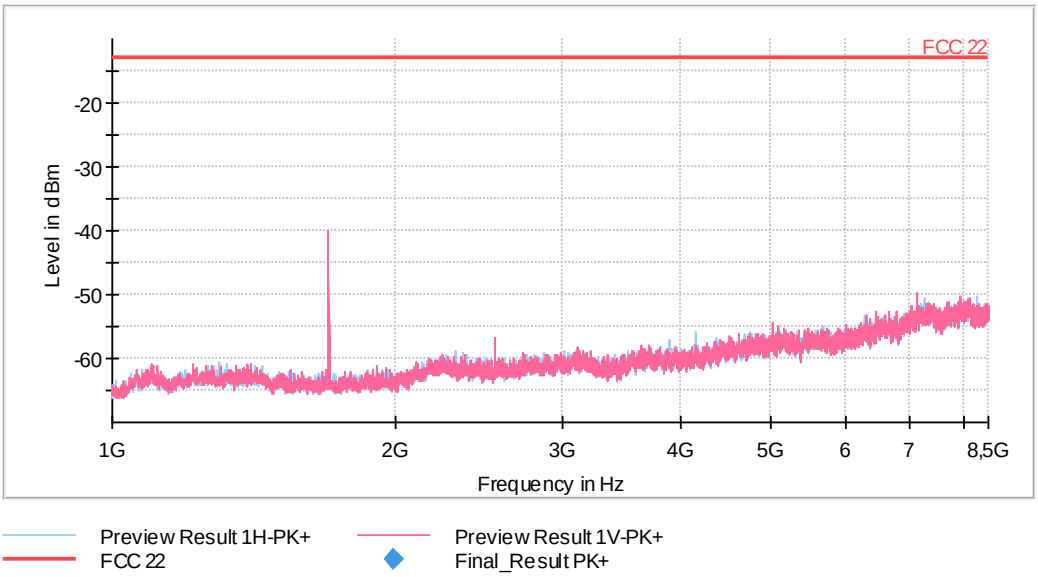
CHANNEL: LOWEST



CHANNEL: MIDDLE



CHANNEL: HIGHEST



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

INDEX

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.

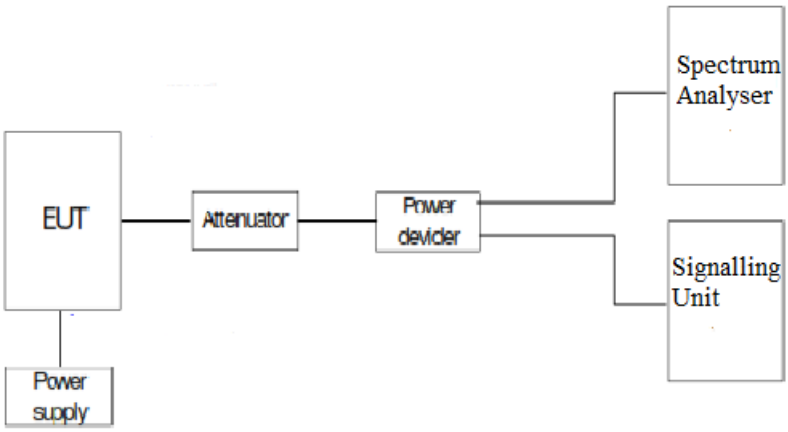
The maximum equivalent isotropically radiated power (e.i.r.p.) is calculated by adding the declared maximum antenna gain (dBi).

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			

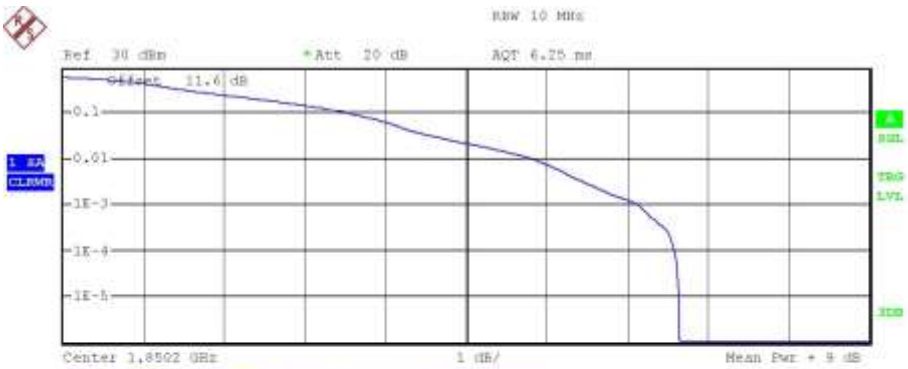
Verdict: PASS

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.

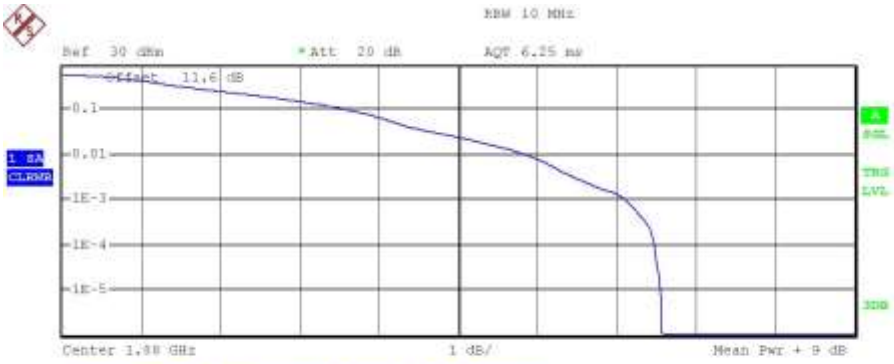
Channel Low:



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

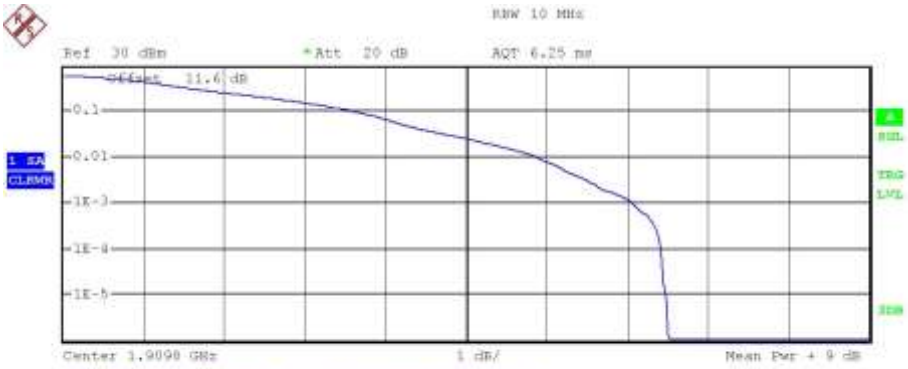
Channel Middle:



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:



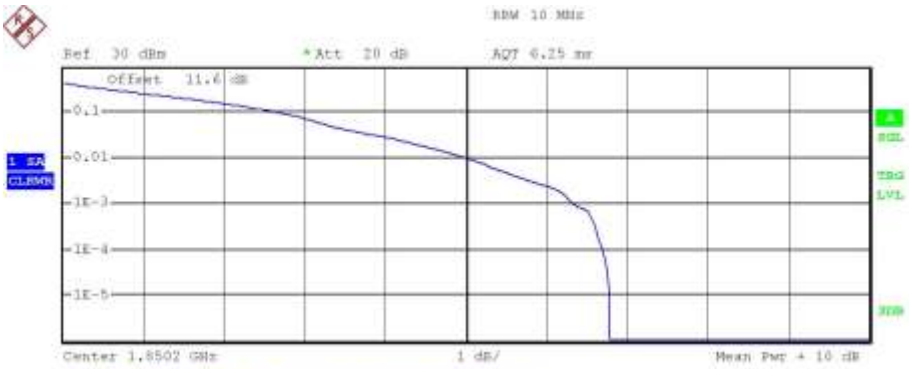
Complementary Cumulative Distribution Function
NOF samples: 100000, Usable BW: 11.2MHz

	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.

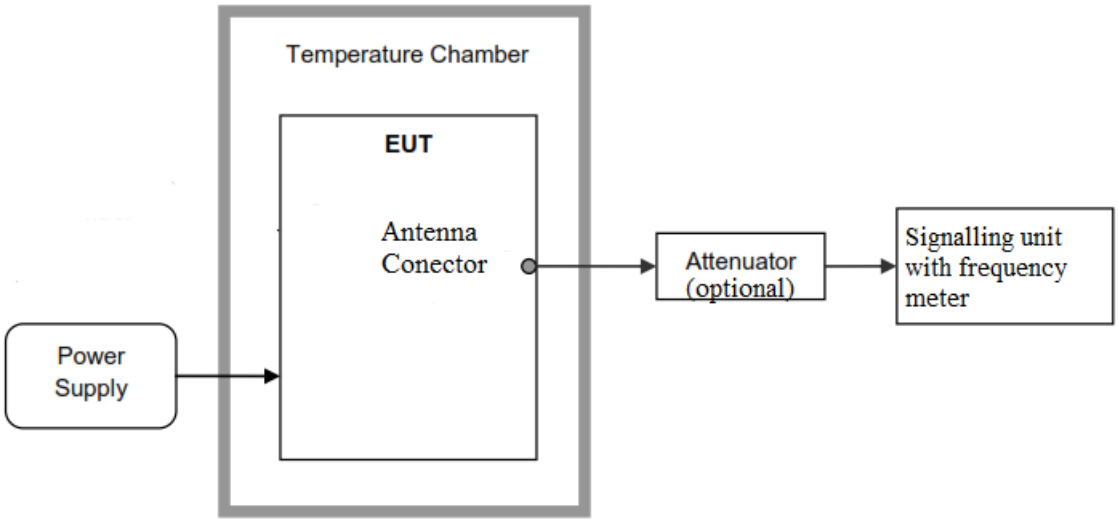
The EUT was set in “Radio Resource Control (RRC) mode” in the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case LTE mode for conducted power was used for the test.

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.

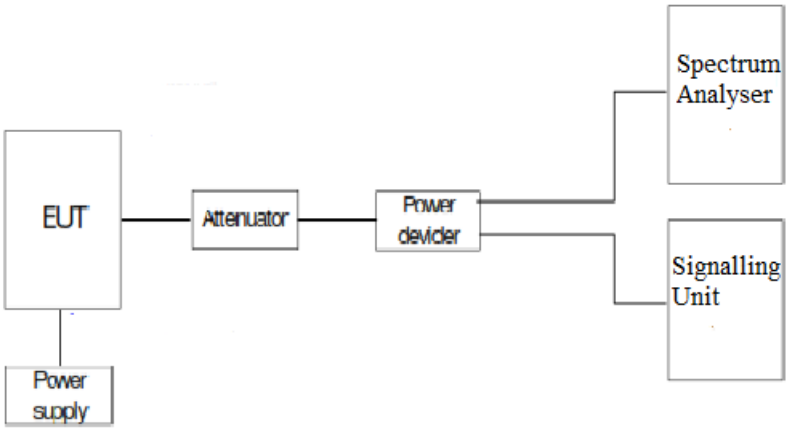
The reference point measurements were made at the RF output terminals of the EUT using an attenuator. power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

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:

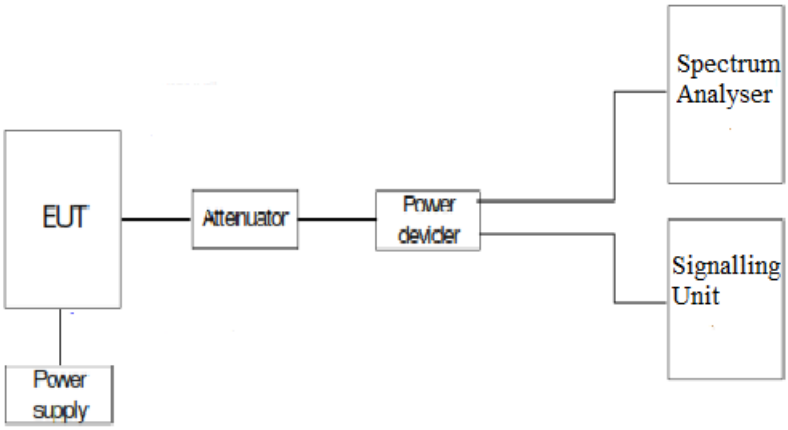
FCC §2.1047

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.

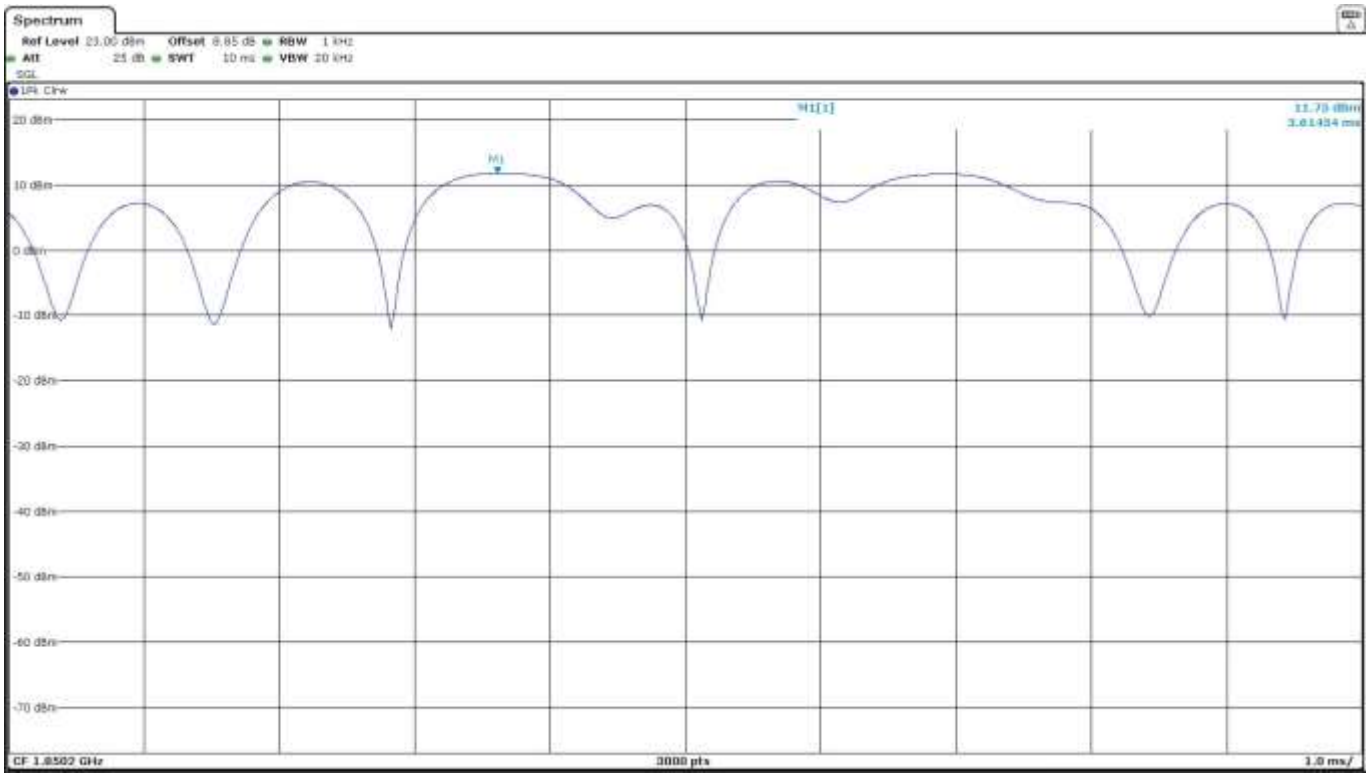
TEST SETUP:



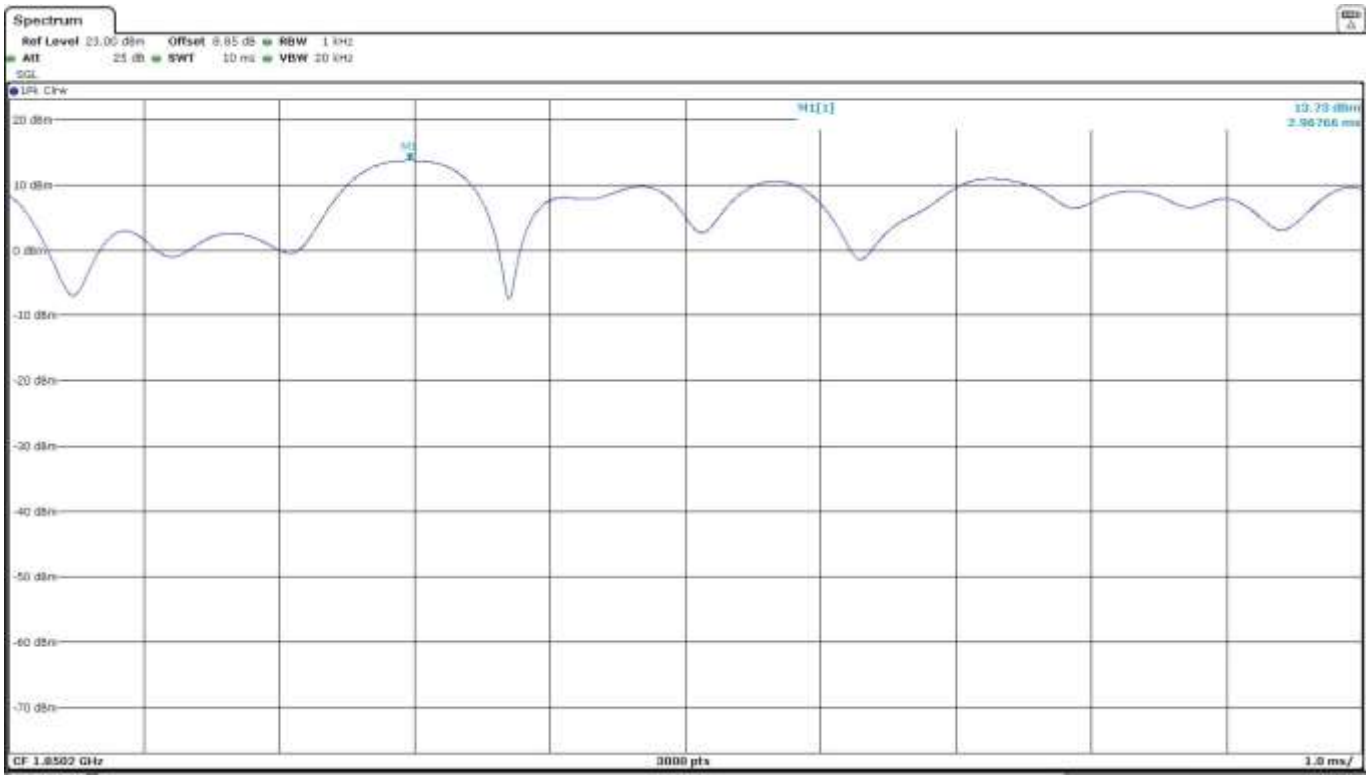
RESULTS:

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:

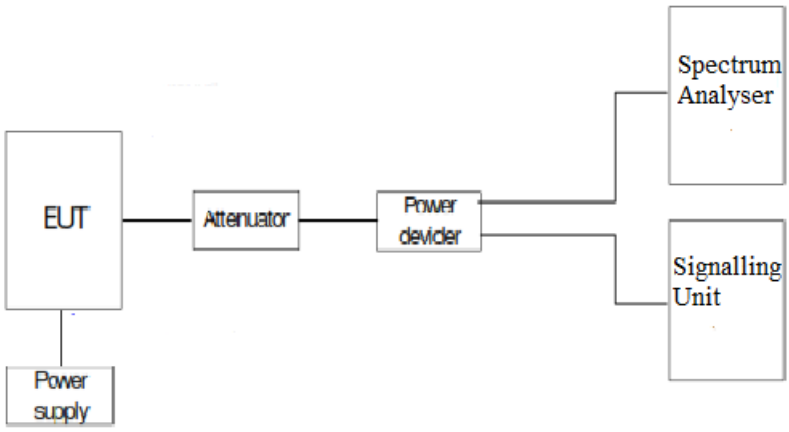
FCC §2.1049. Measurements required: Occupied bandwidth.

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		

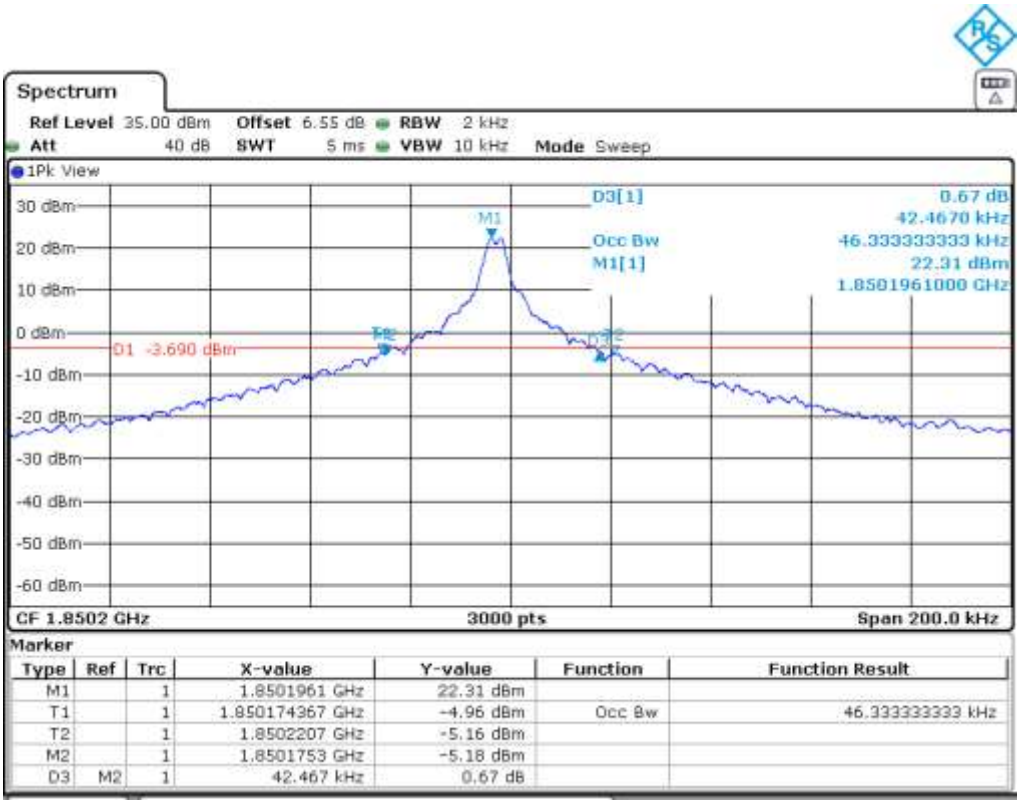
12 Tones 15 kHz. π/4 - QPSK MODULATION

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		

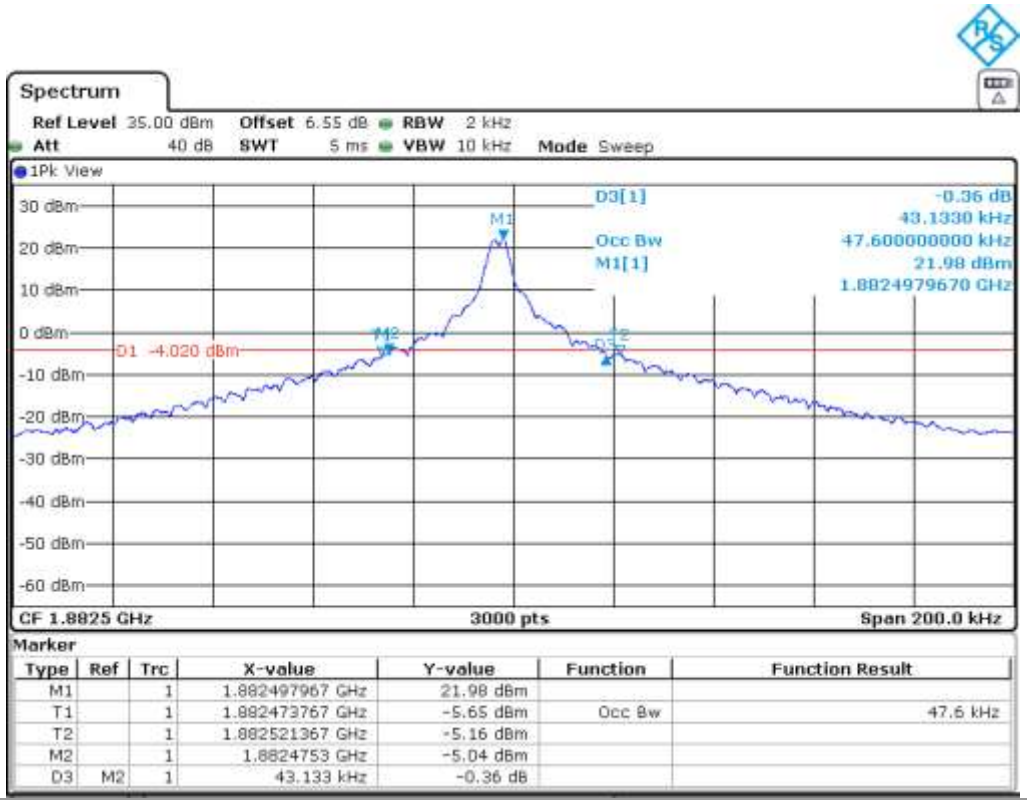
RESULTS:
NBIoT BAND 25.

Tone 3.75 kHz. π/2 - BPSK MODULATION

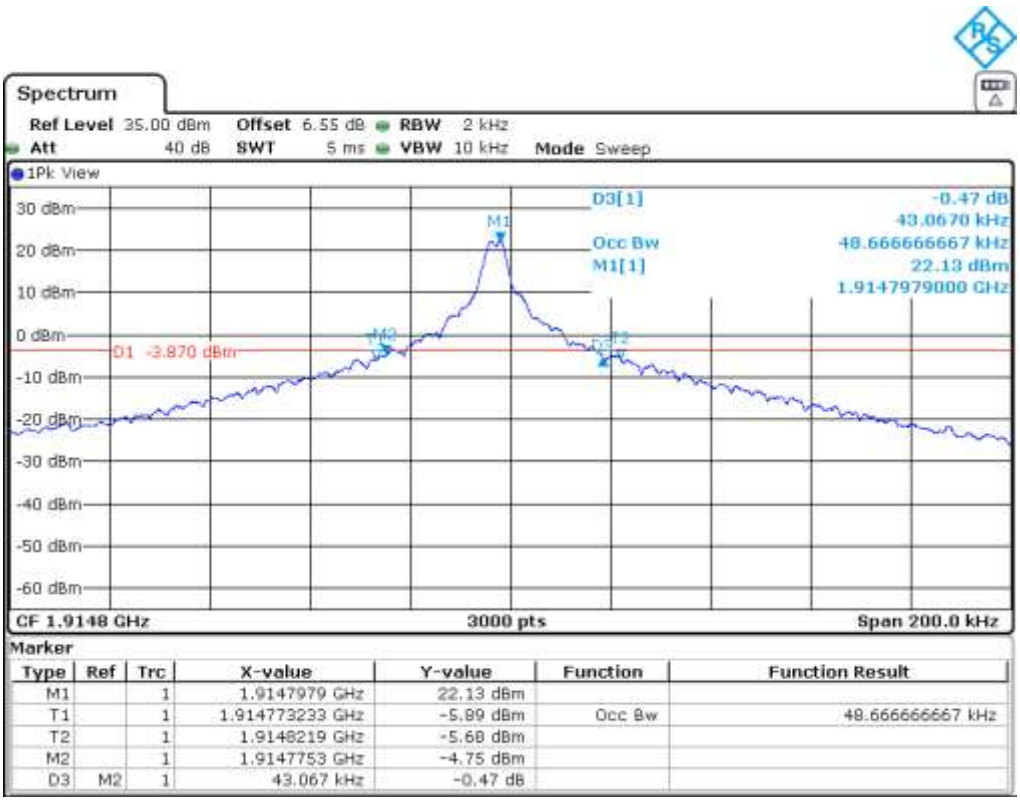
Lowest Channel



Middle Channel

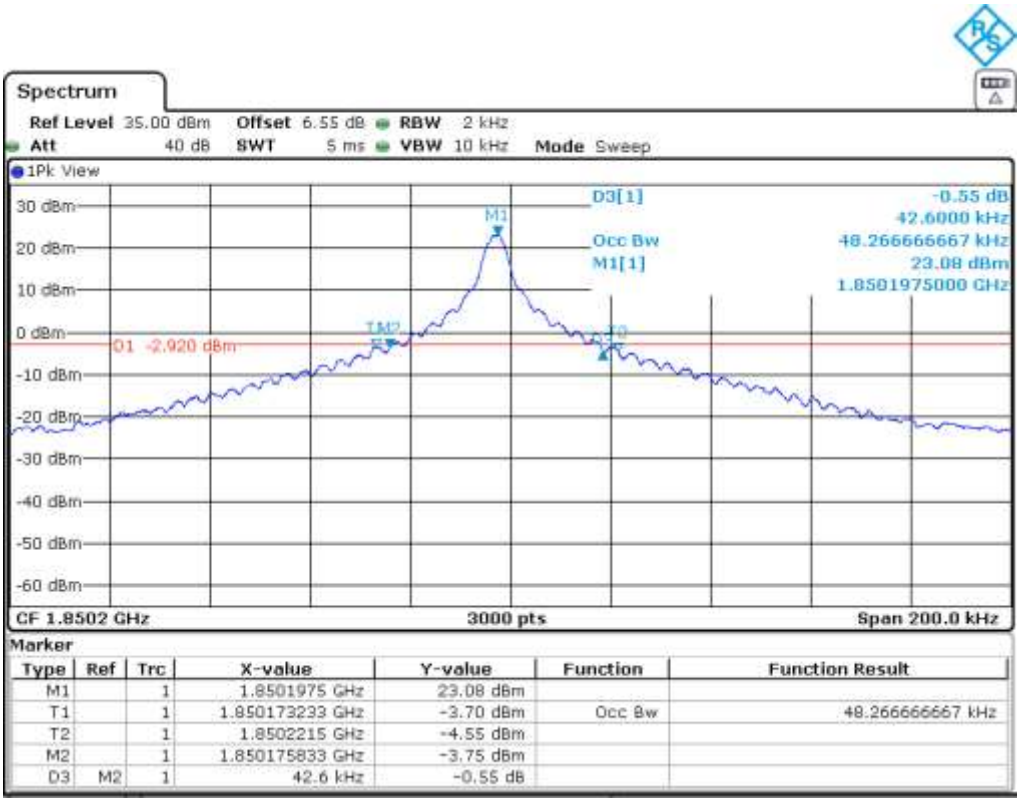


Highest Channel

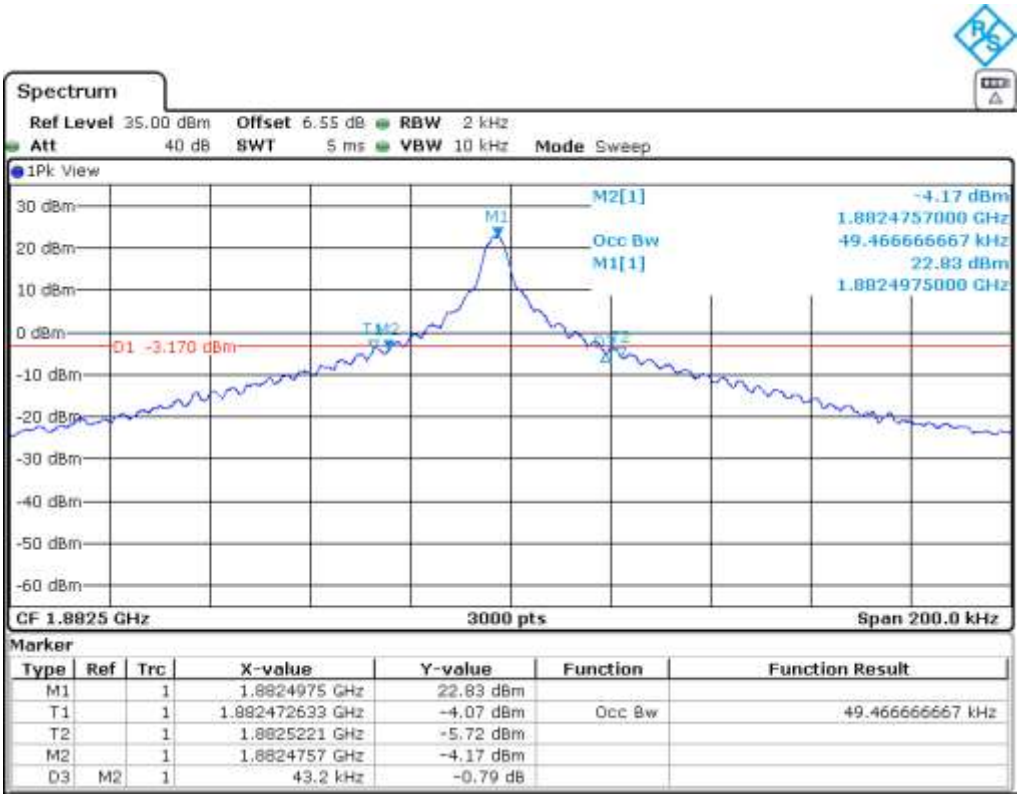


Tone 3.75 kHz. π/4 - QPSK MODULATION

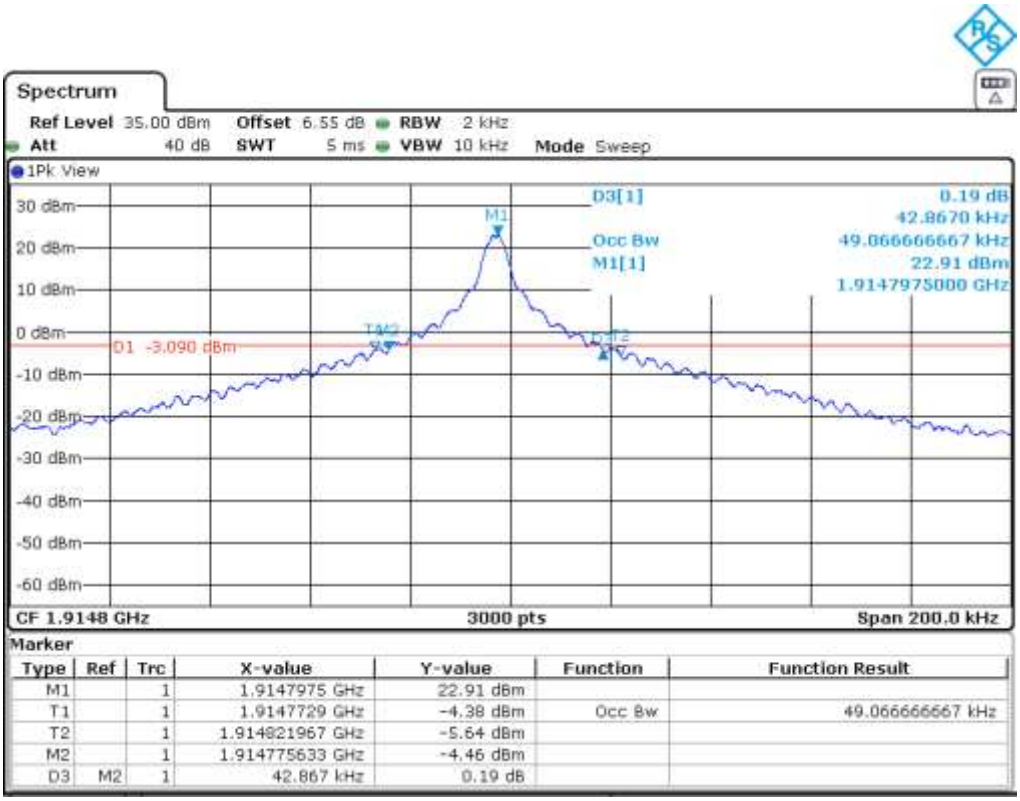
Lowest Channel



Middle Channel

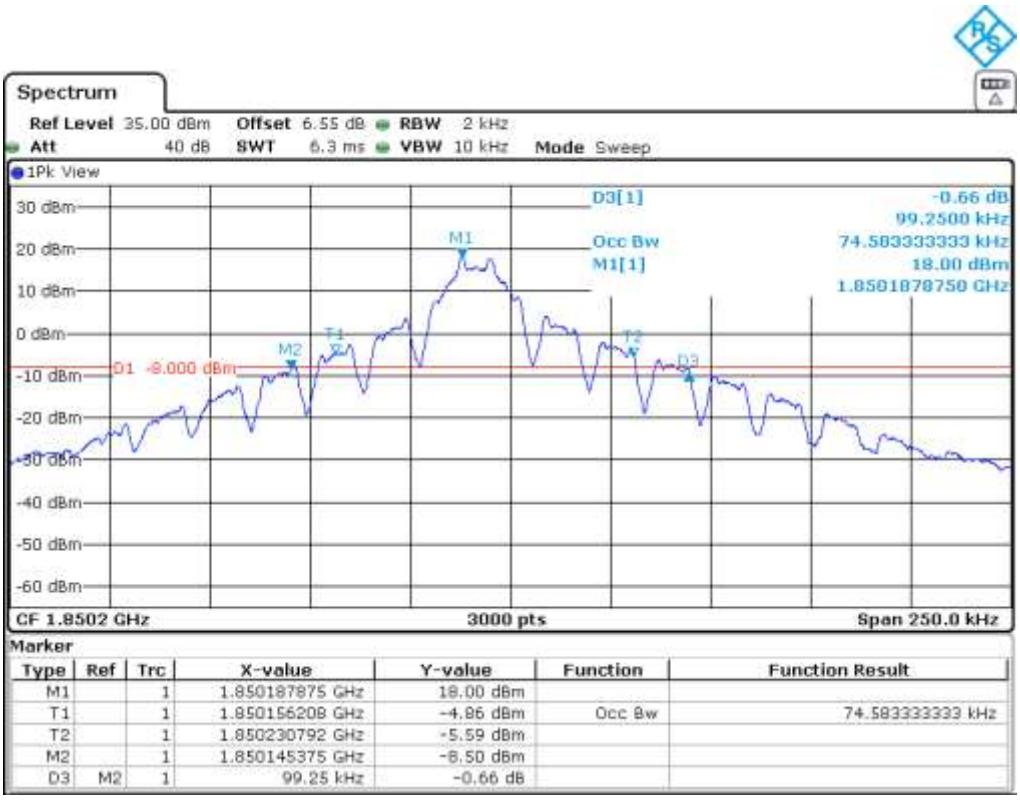


Highest Channel

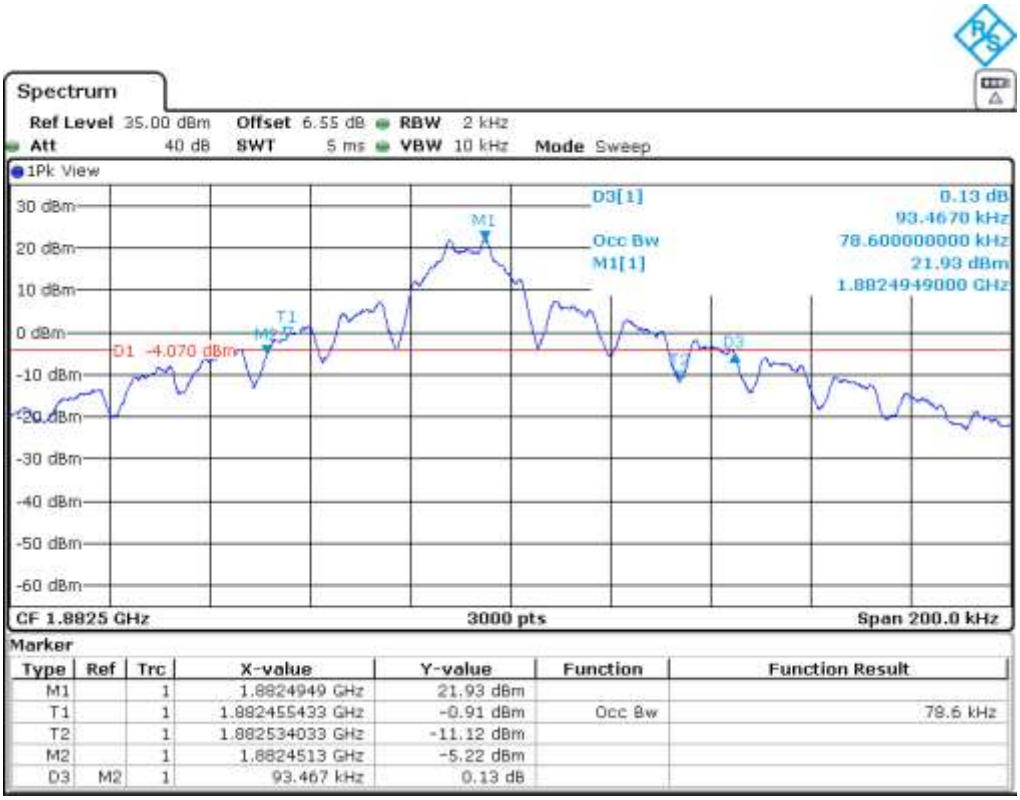


Tone 15 kHz. π/2 - BPSK MODULATION

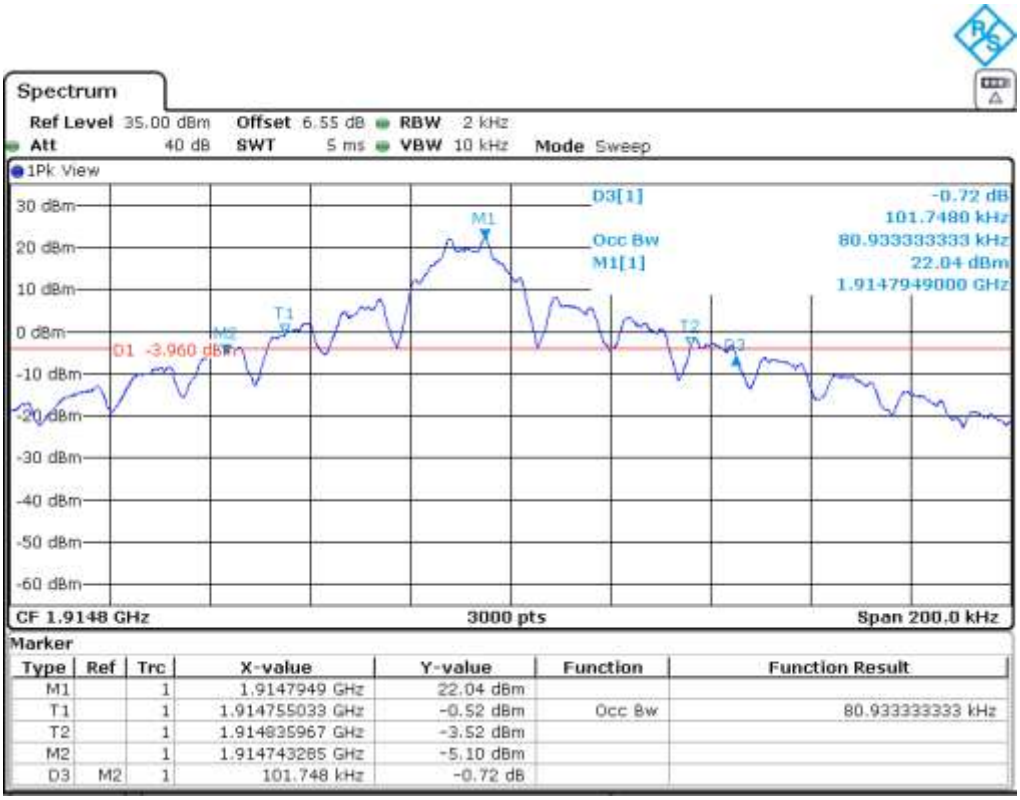
Lowest Channel



Middle Channel

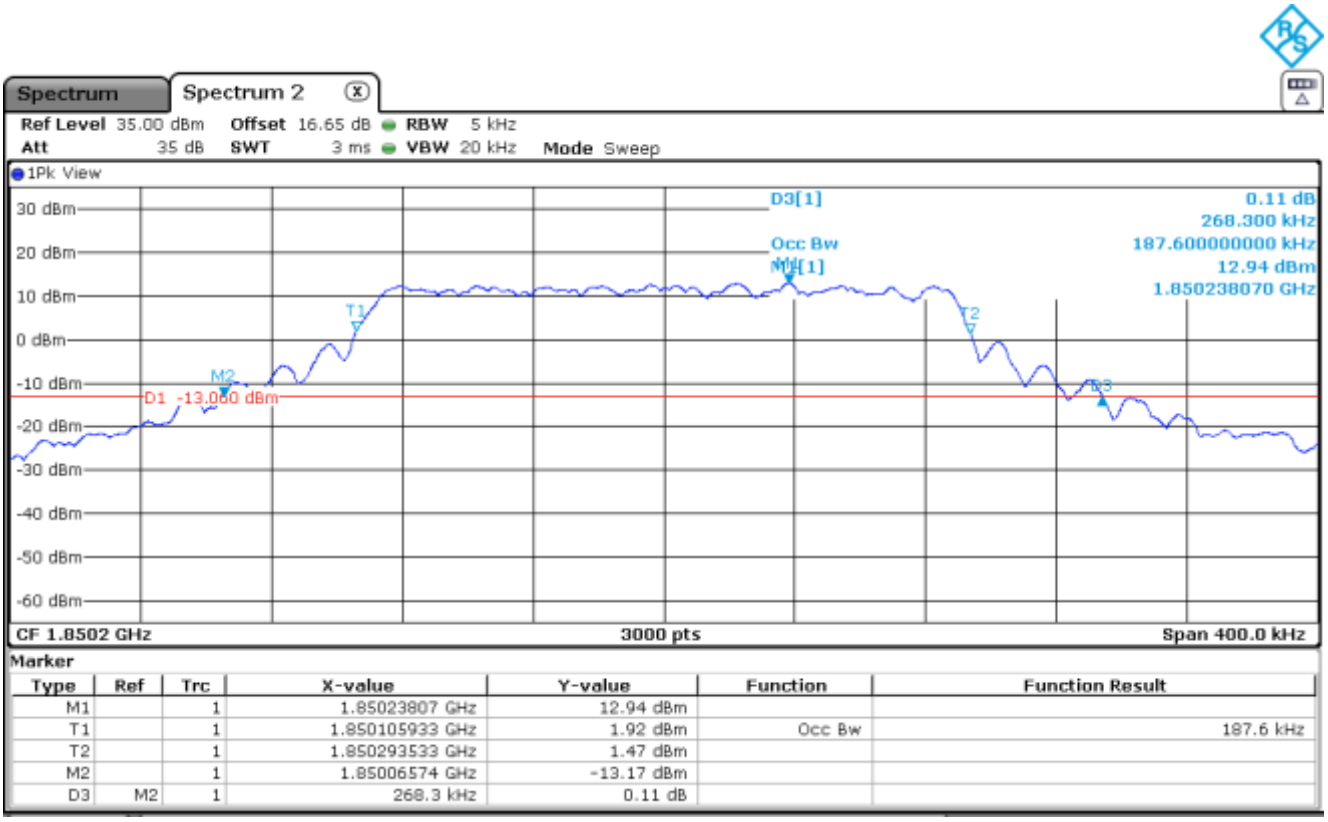


Highest Channel

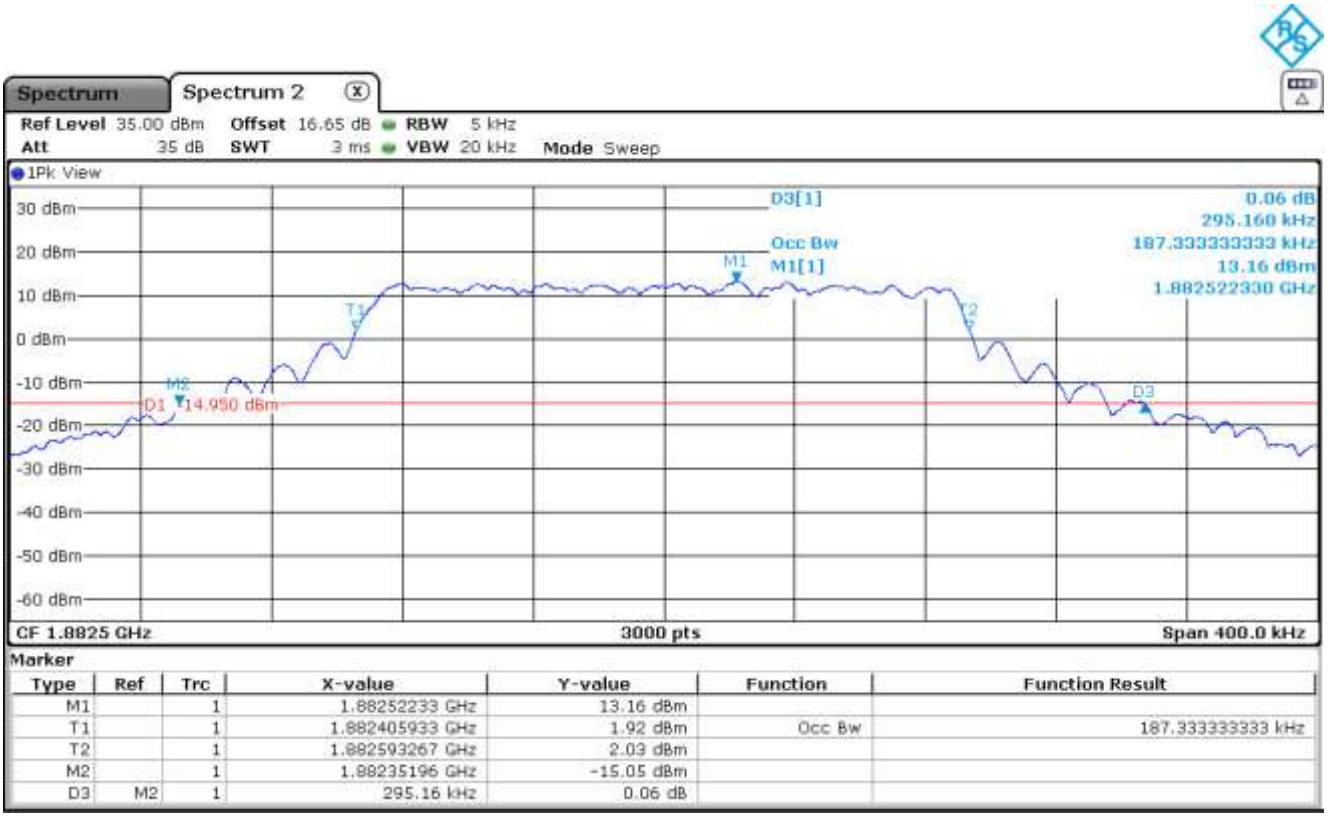


12 Tones 15 kHz. π/4 - QPSK MODULATION

Lowest Channel



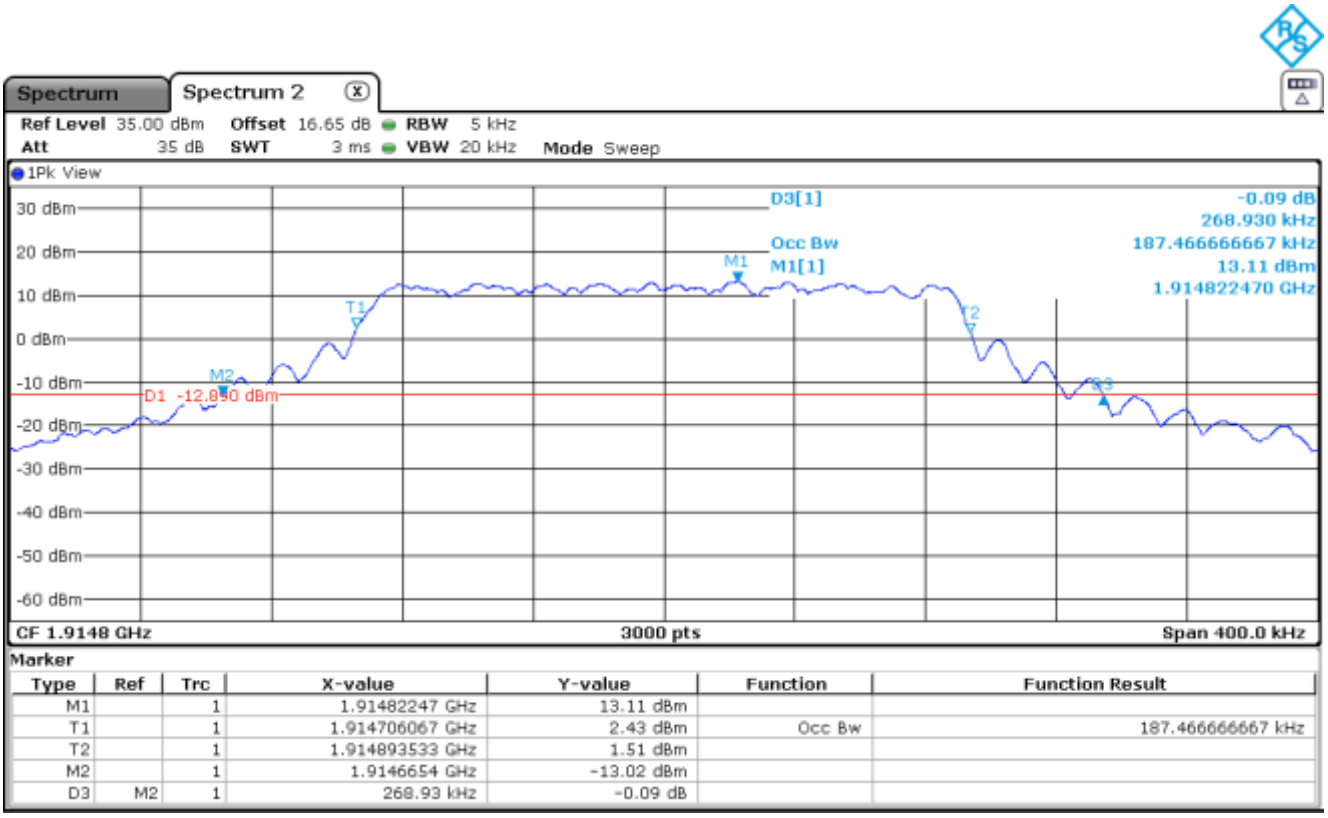
Middle Channel



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.

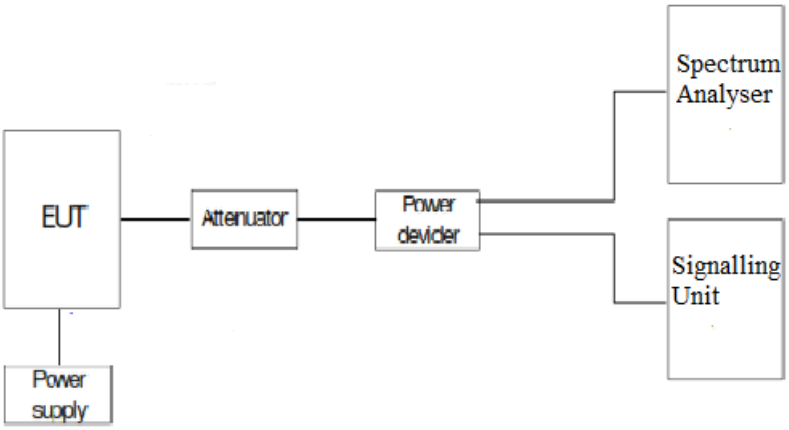
Measurement Limit**:**

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.

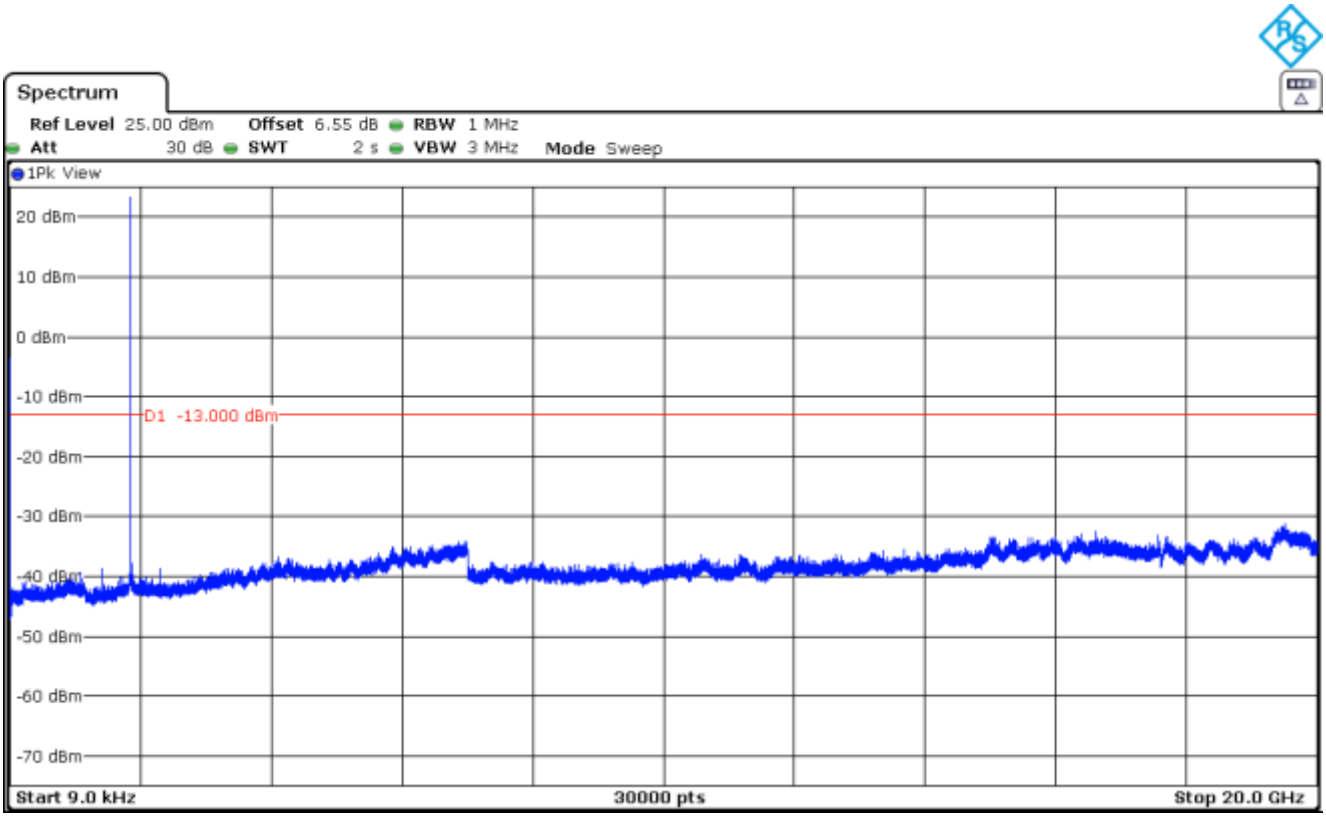
Measurement uncertainty (dB): < ± 2.76

Verdict: PASS

RESULTS (see plots in next pages)

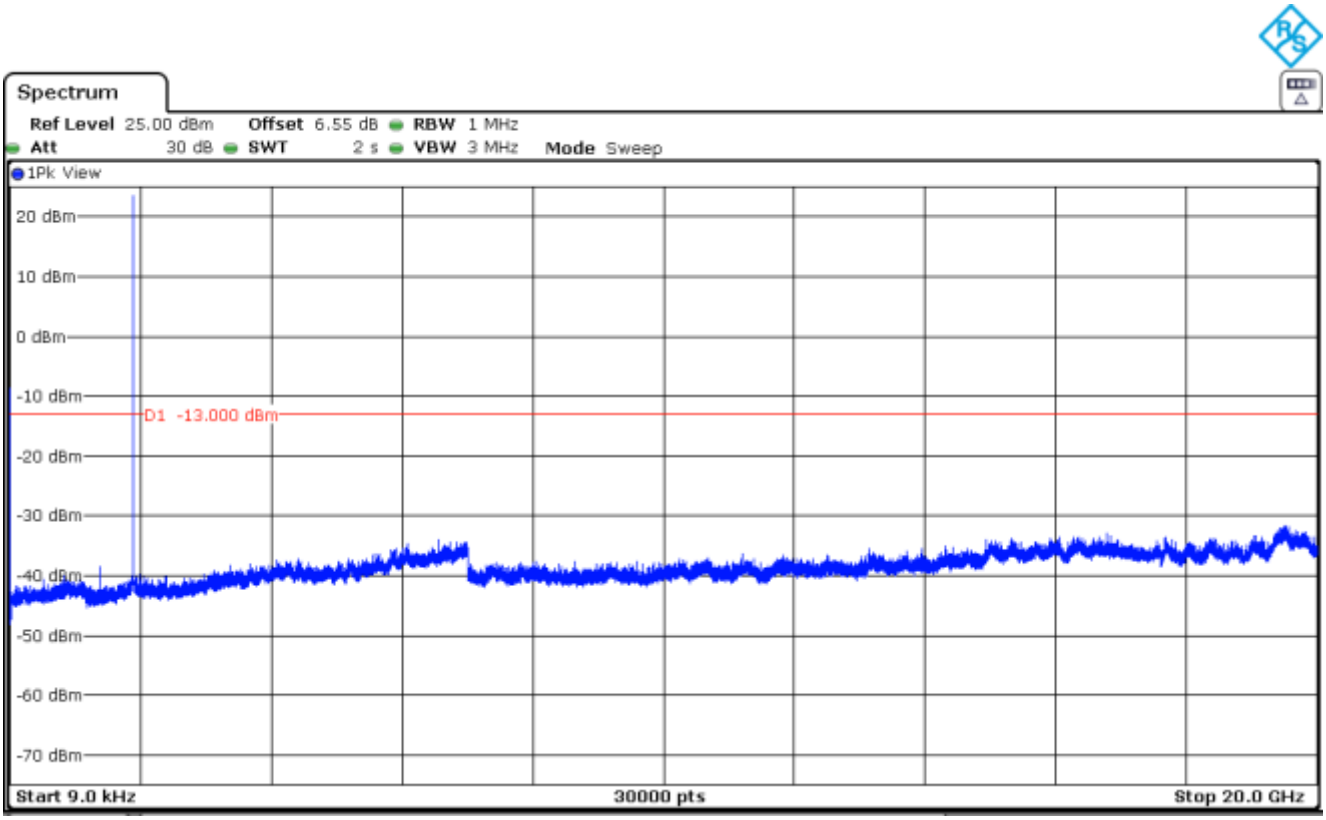
NBIoT BAND 25 (Tone 3.75 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST



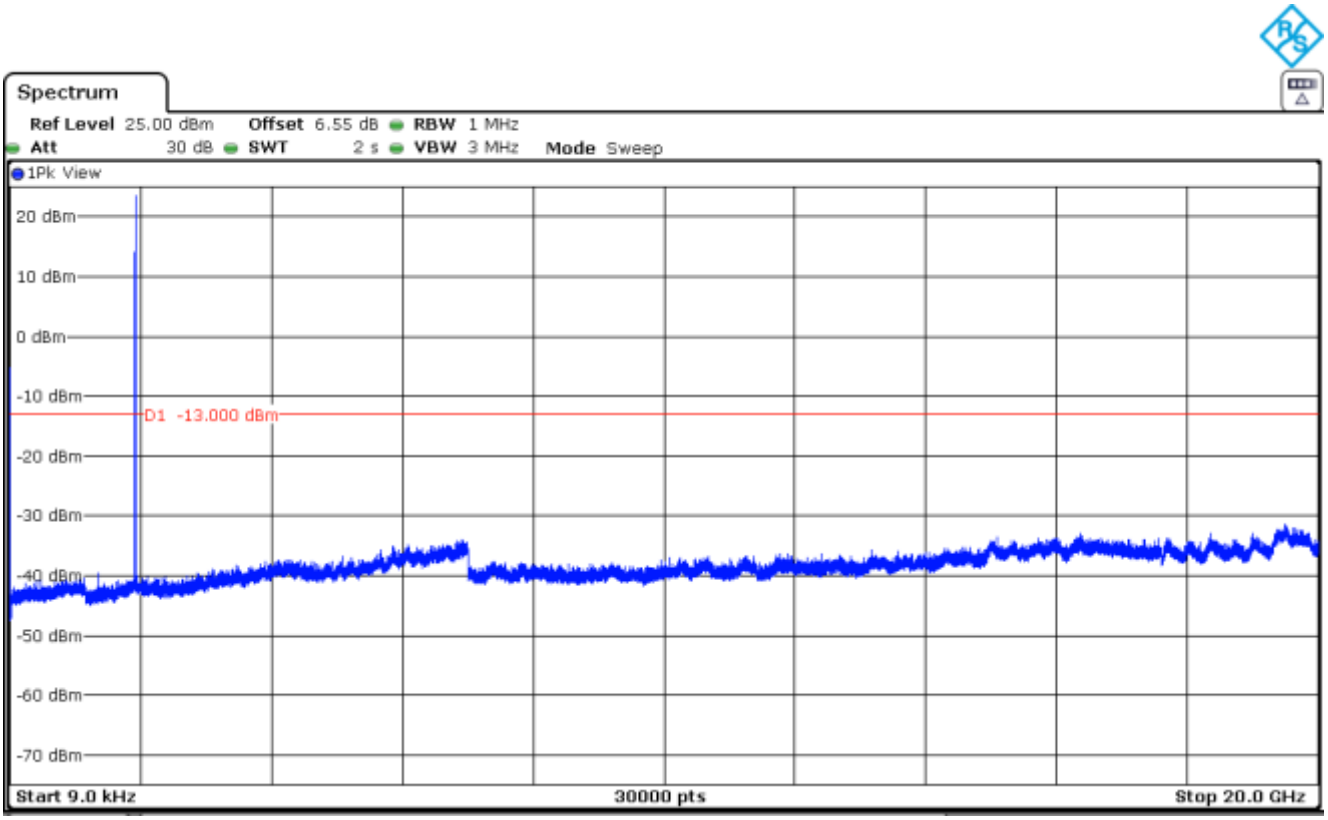
Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE



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

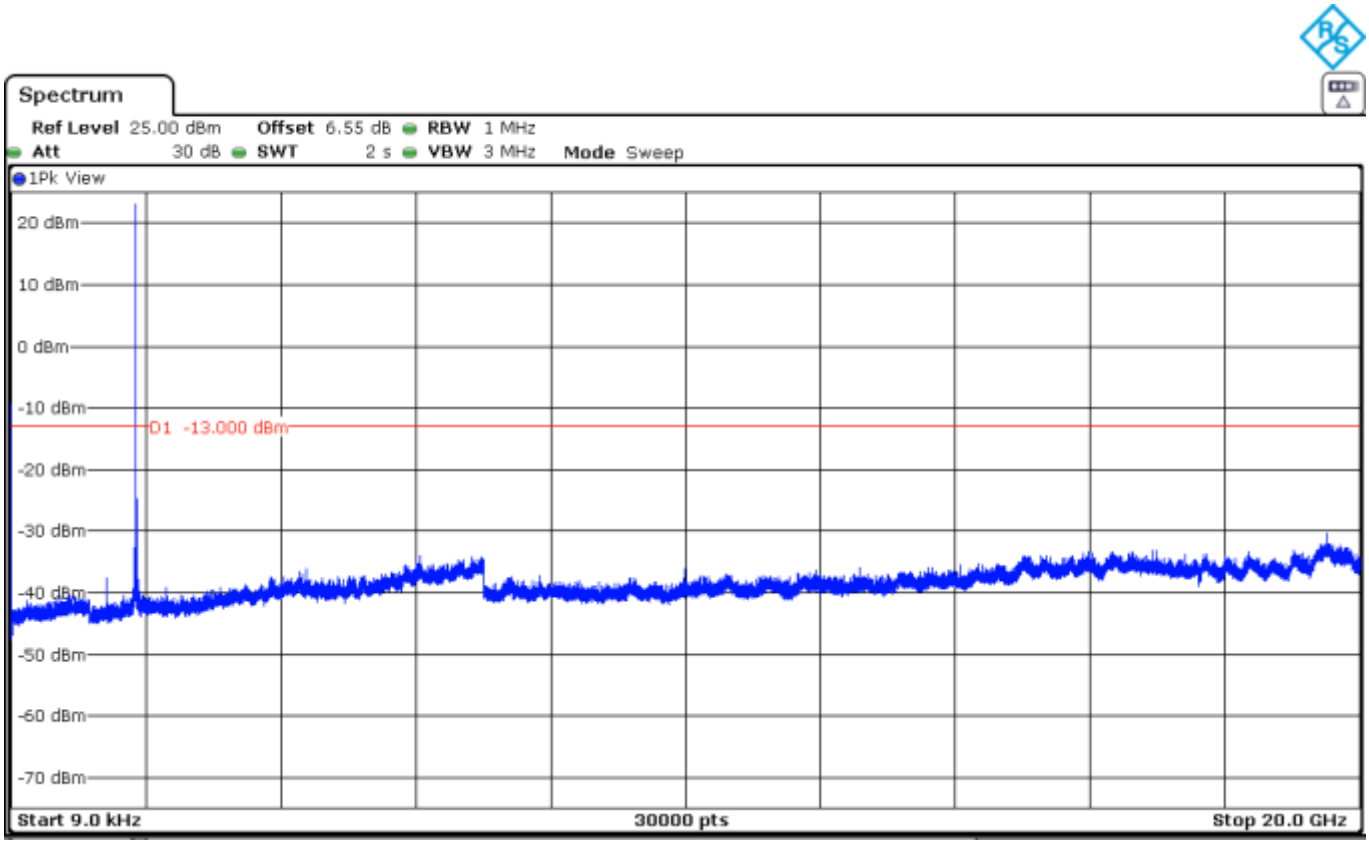
3. CHANNEL: HIGHEST



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

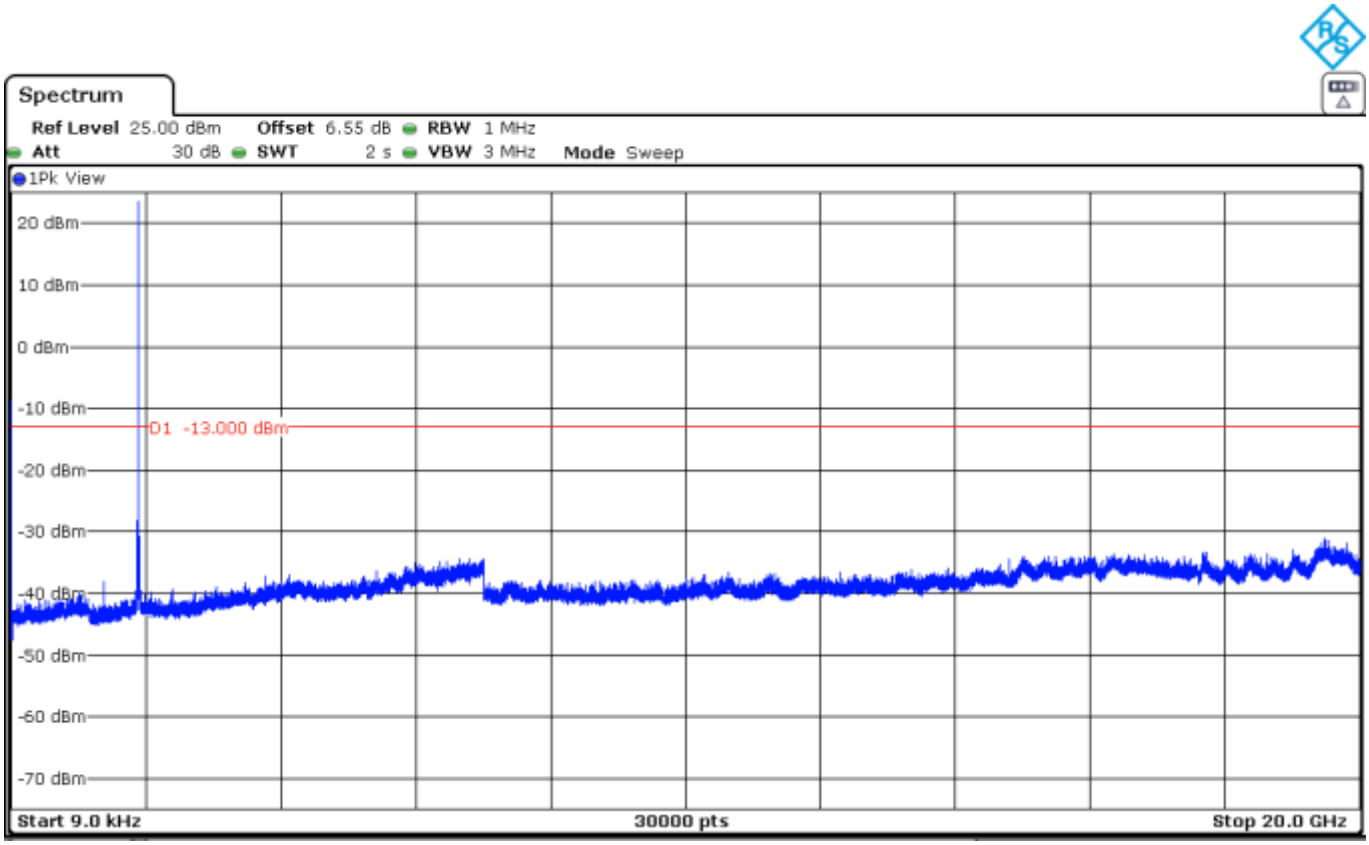
NBIoT BAND 25 (Tone 15 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST



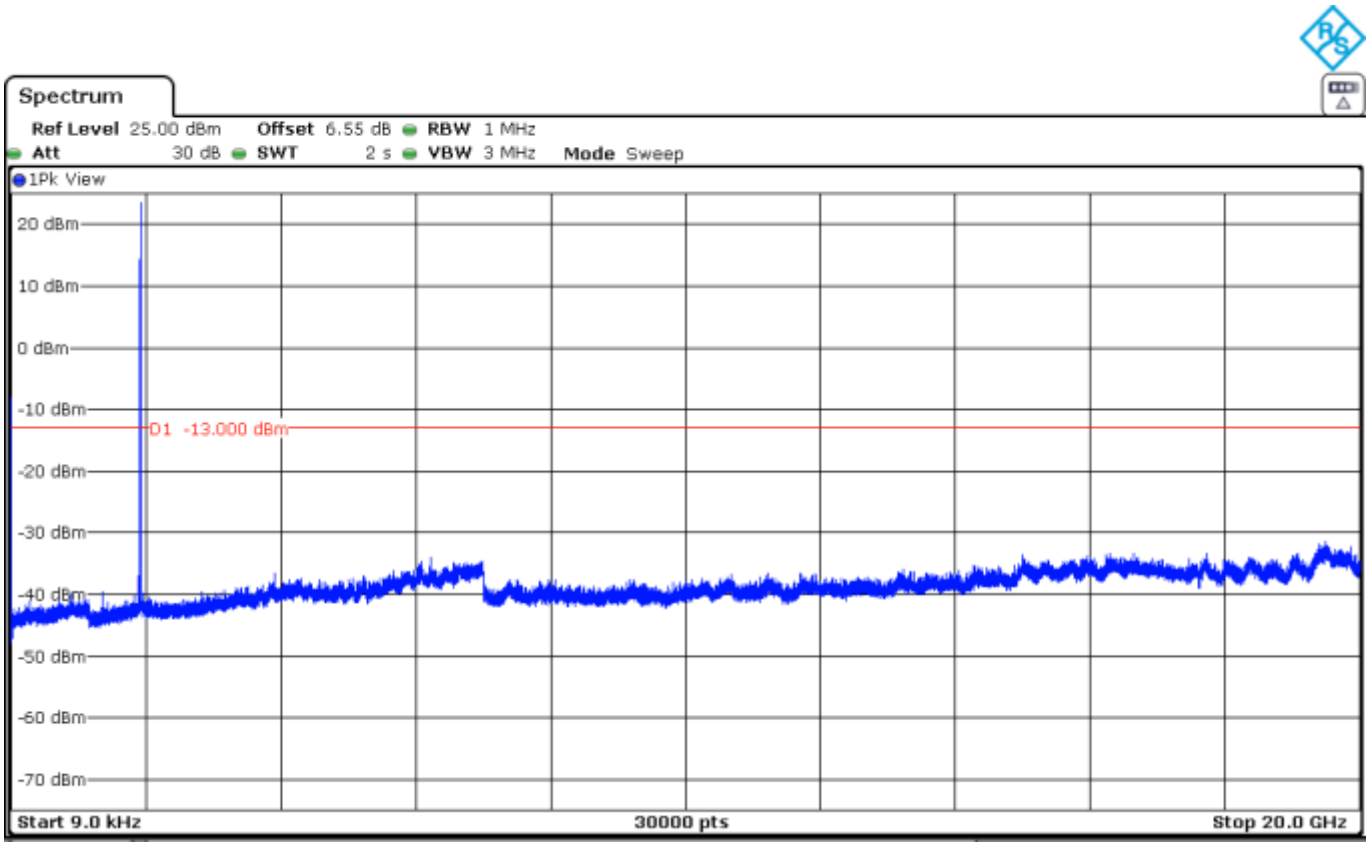
Note: The peak above the limit is the carrier frequency.

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.

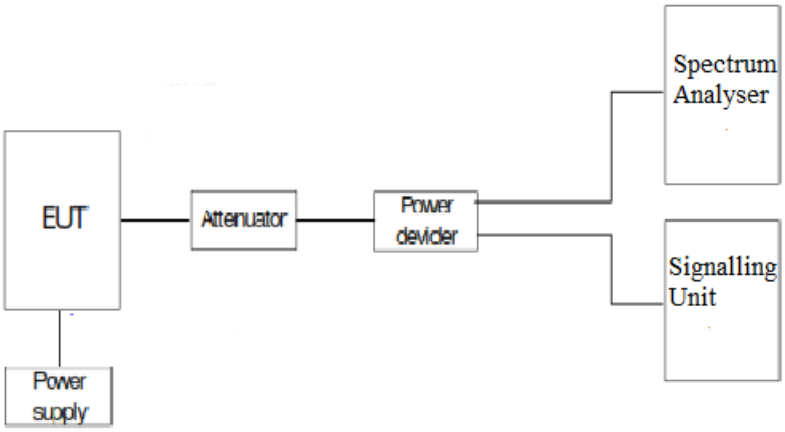
The configuration of modulation which is the worst case for conducted power was used.

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:

$$Po\ (dBm) – [43 + 10 \log (Po \text{ in mwatts}) - 30] = - 13\ dBm$$

TEST SETUP:



RESULTS:

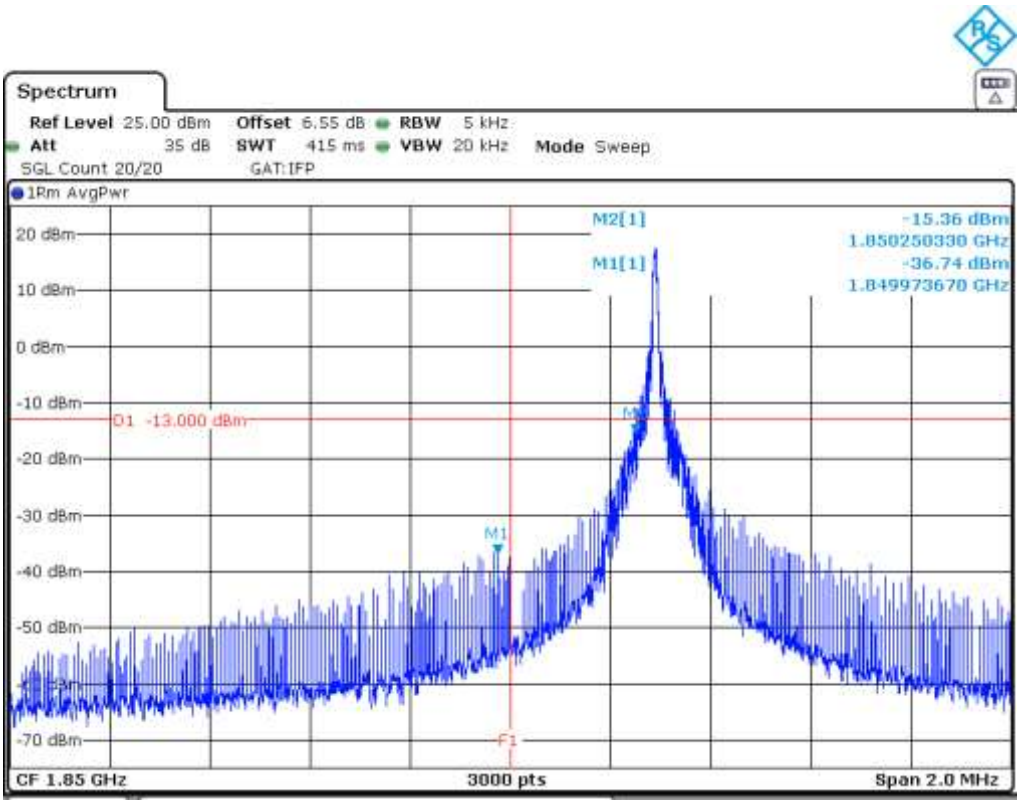
NBIoT	Tone 3.75 kHz. π/4 - QPSK Offset 0 MCS/TBS=3	Tone 15kHz. π/2 - BPSK Offset 0 MCS/TBS=0	12 Tone 15kHz. π/2 - BPSK Offset 0 MCS/TBS=0
Maximum measured level at lowest Block Edge at antenna port (dBm)	-36.74	-22.02	-23.99

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

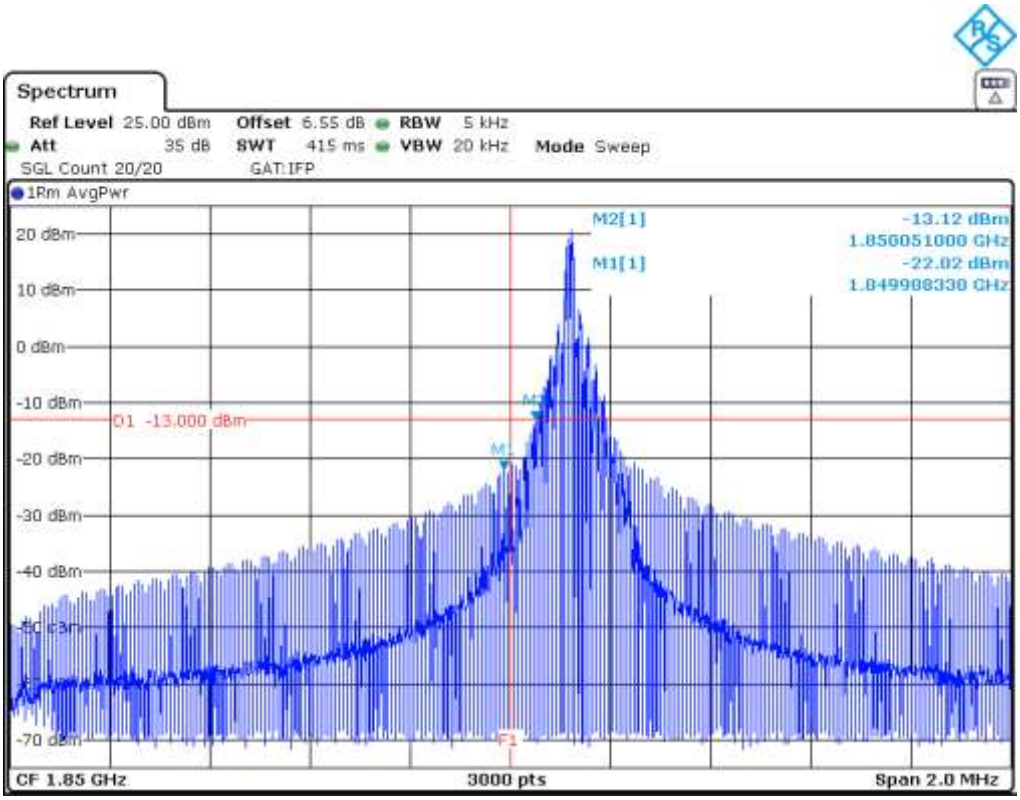
Measurement uncertainty = ±1.57 dB.

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

Lowest Channel:

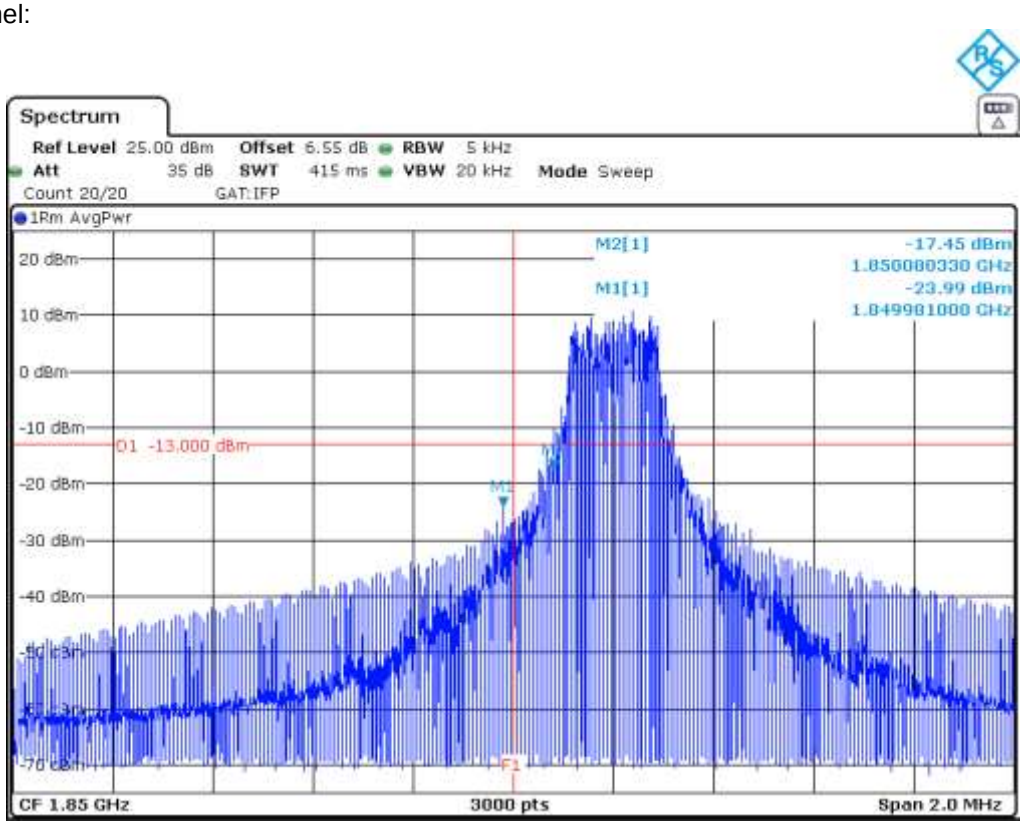


NBIoT BAND 25 (Tone 15 kHz. π/2 - BPSK Offset 0 MODULATION)
Lowest Channel:



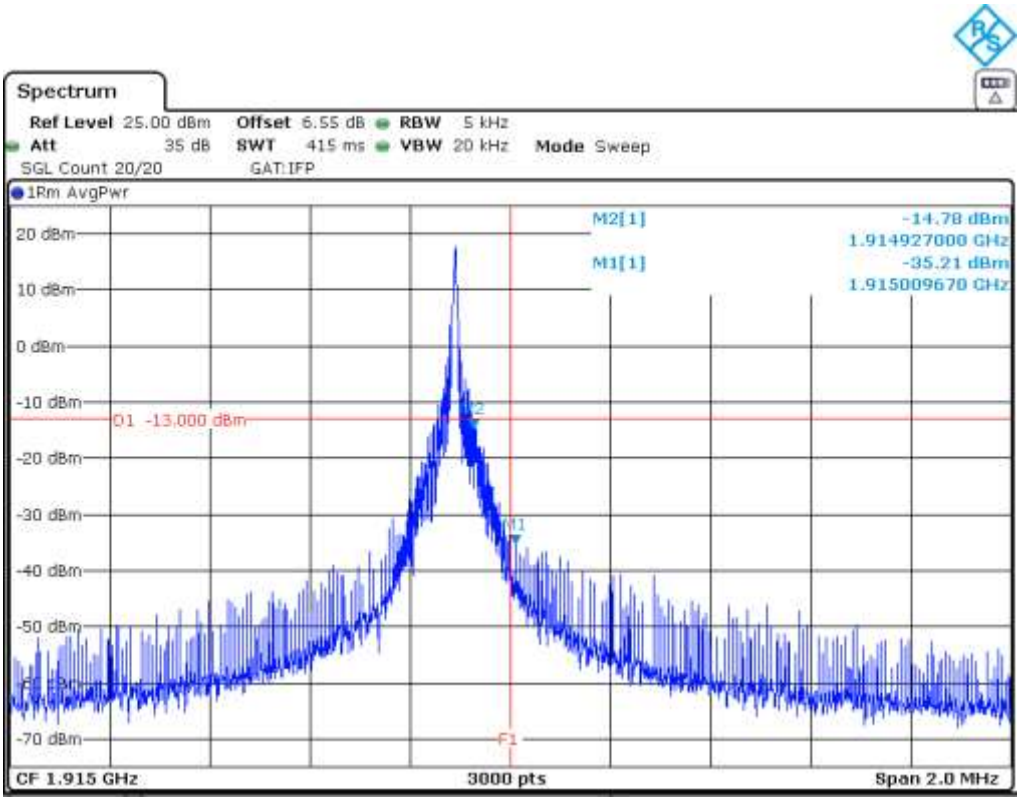
NBIoT BAND 25 (12 Tones 15 kHz. π/4 - QPSK Offset 0 MODULATION)

Lowest Channel:



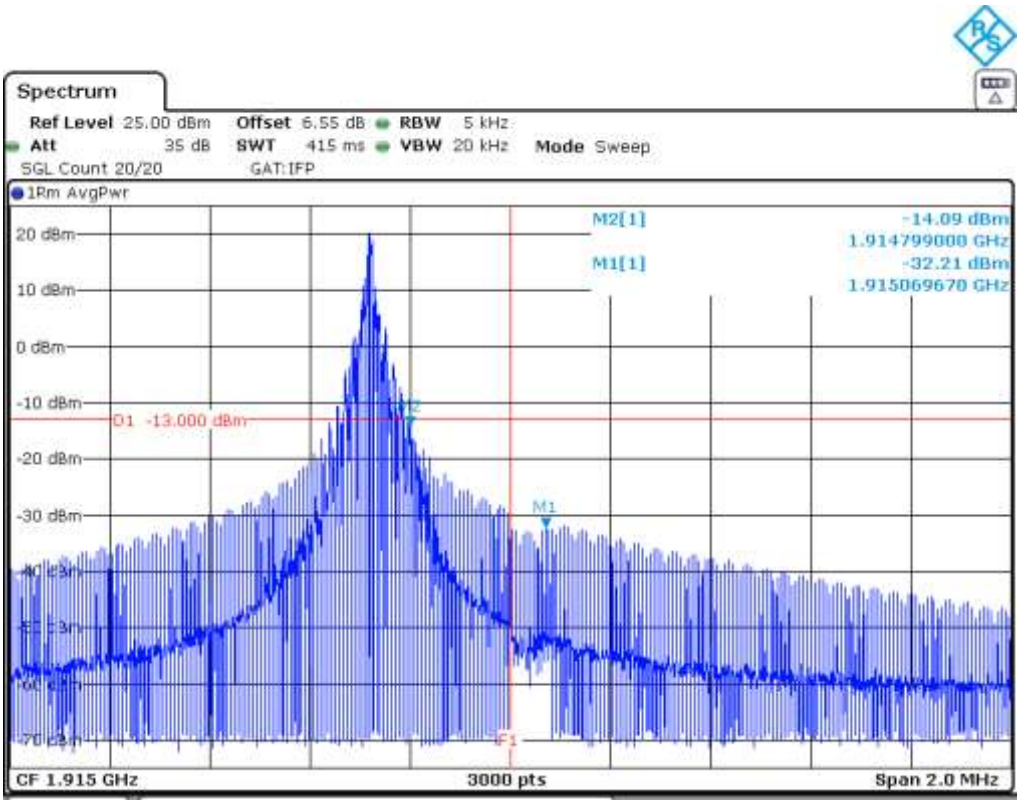
NBIoT BAND 25 (Tone 3.75 kHz. π/4 - QPSK Offset 47 MODULATION)

Highest Channel:



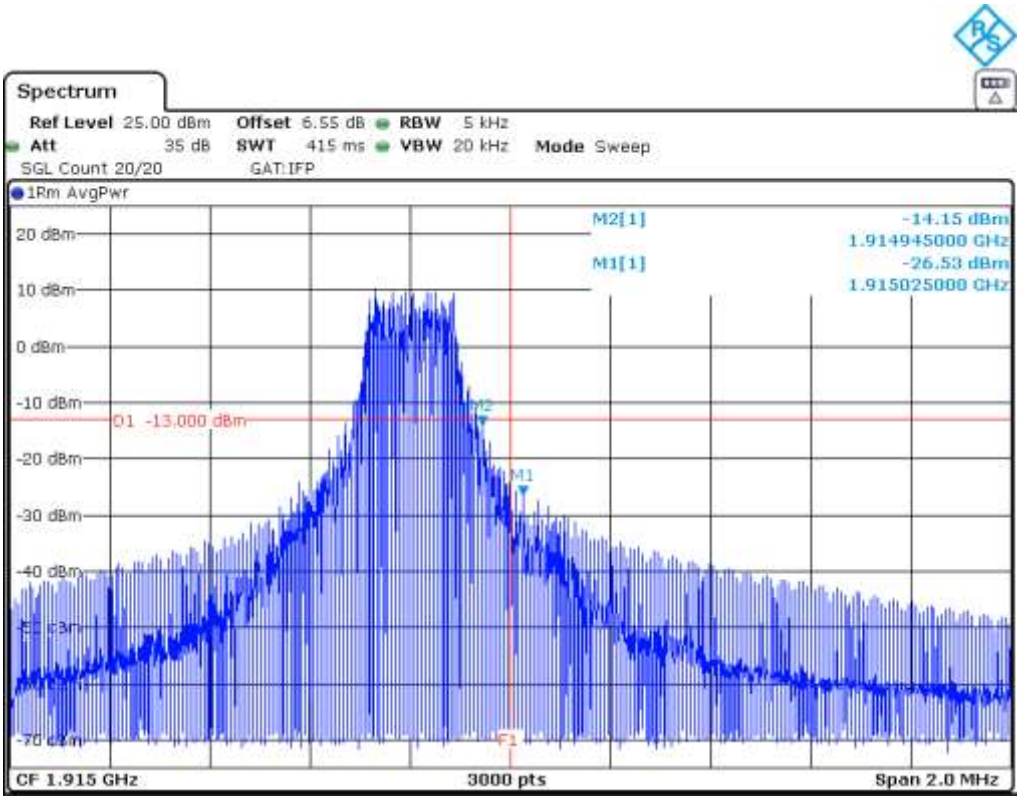
NBIoT BAND 25 (Tone 15 kHz. π/2 - BPSK Offset 11 MODULATION)

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

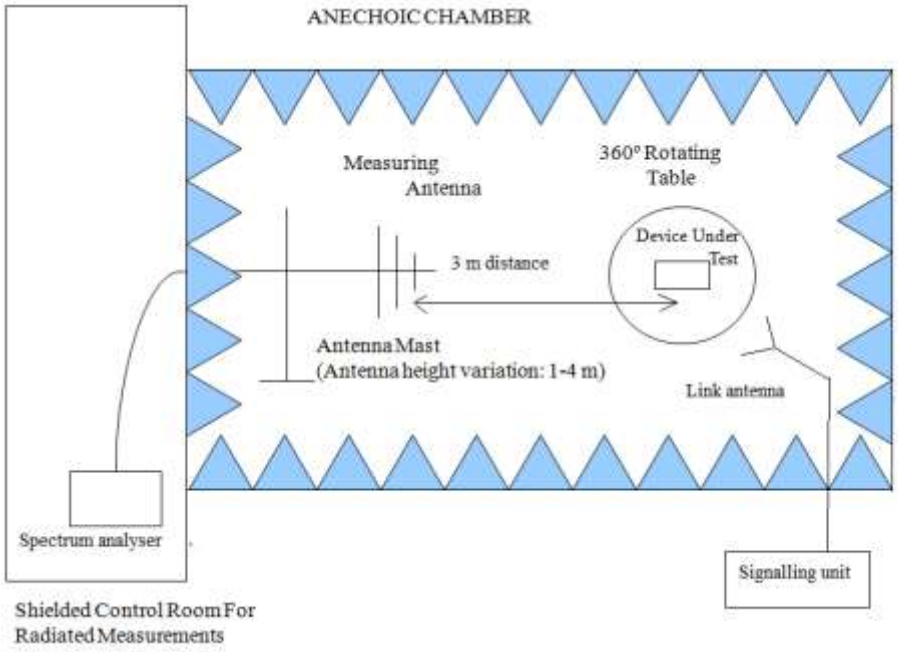
Measurement Limit:

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:

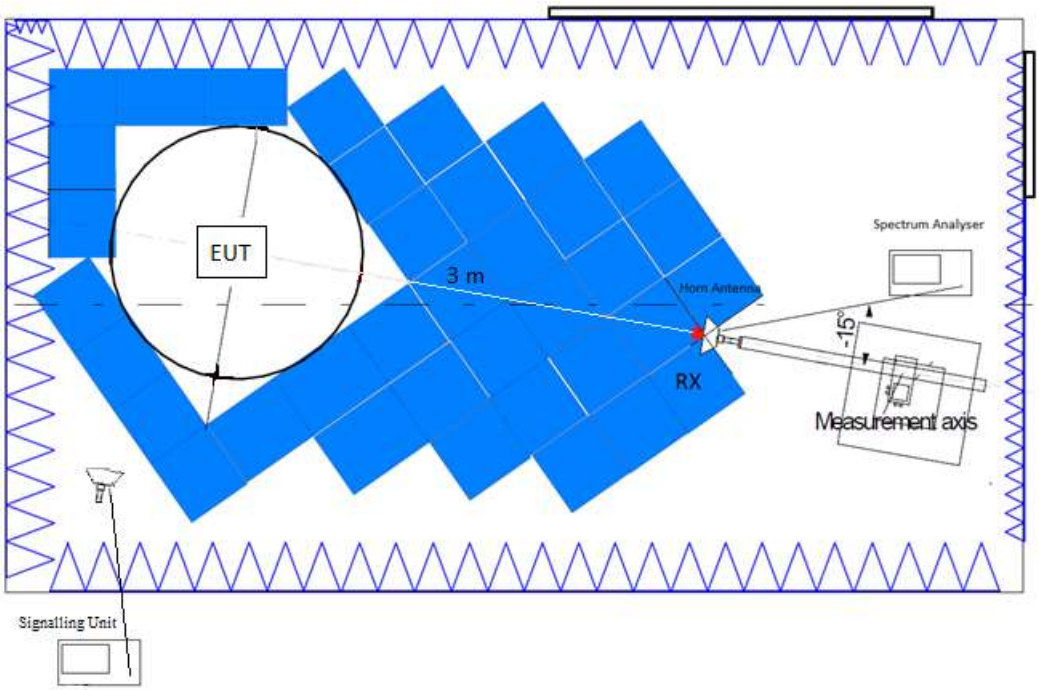
Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = - 13 dBm

TEST SETUP

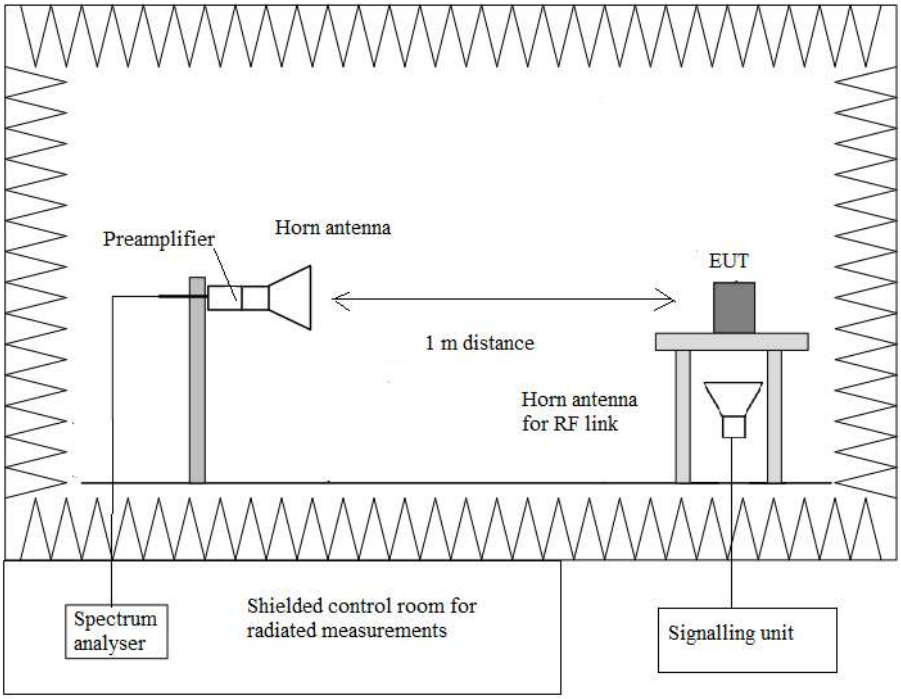
Radiated measurements below 1 GHz.



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.

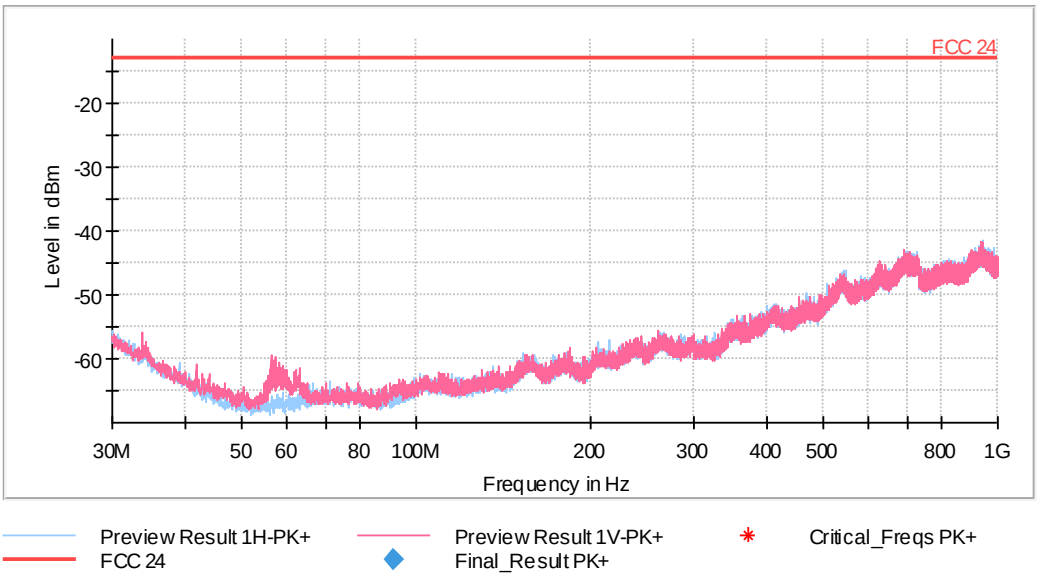
Frequency range 18 GHz-20 GHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

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

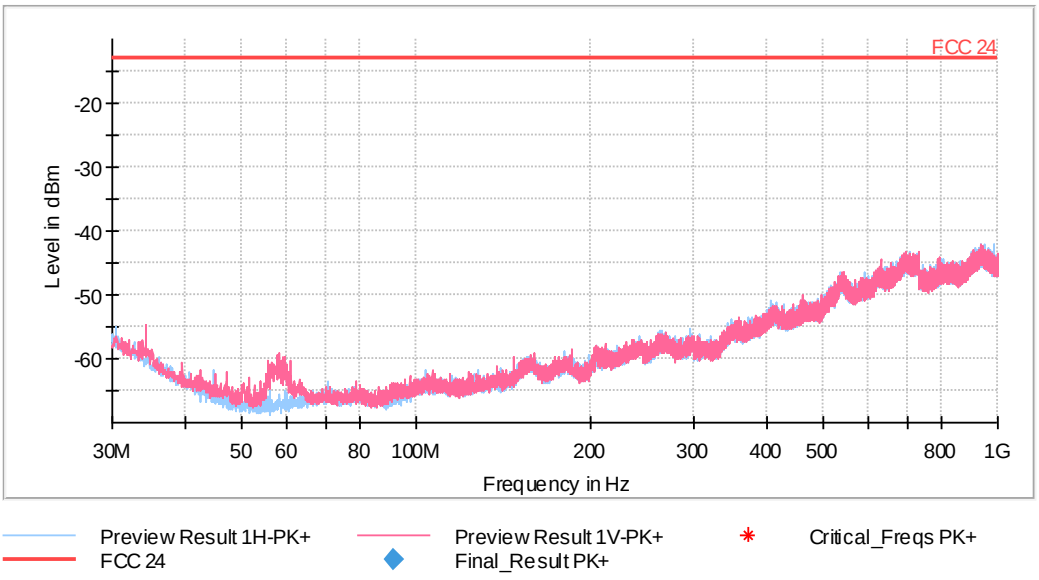
Verdict: PASS

FREQUENCY RANGE 30 MHz-1000 MHz.

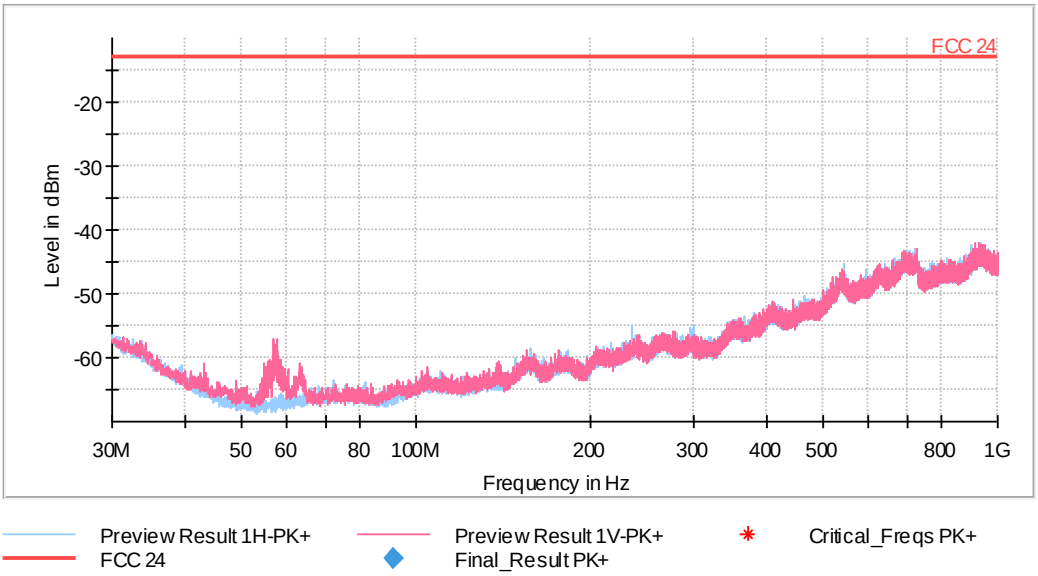
CHANNEL: LOWEST



CHANNEL: MIDDLE

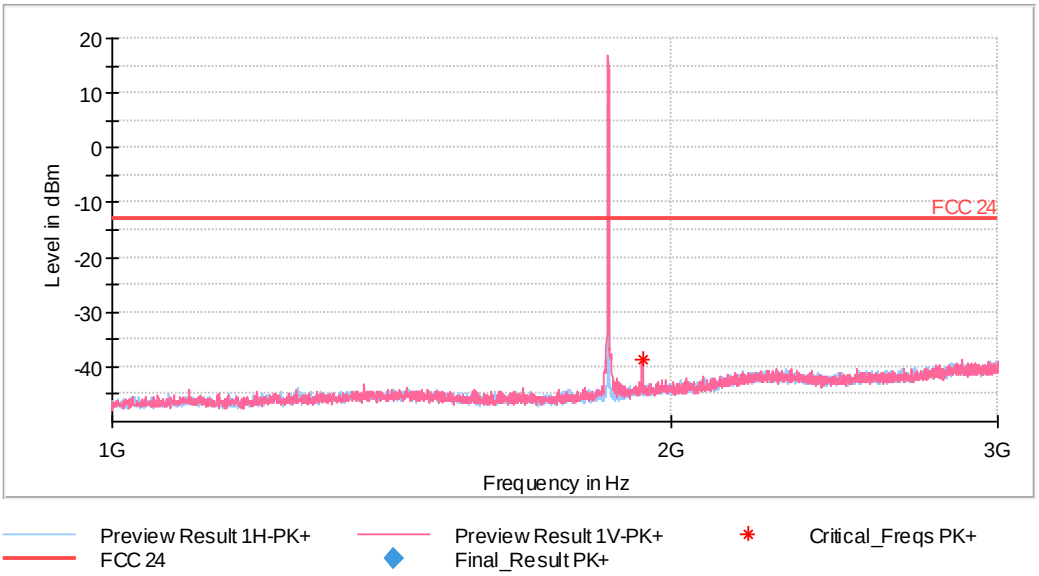


CHANNEL: HIGHEST



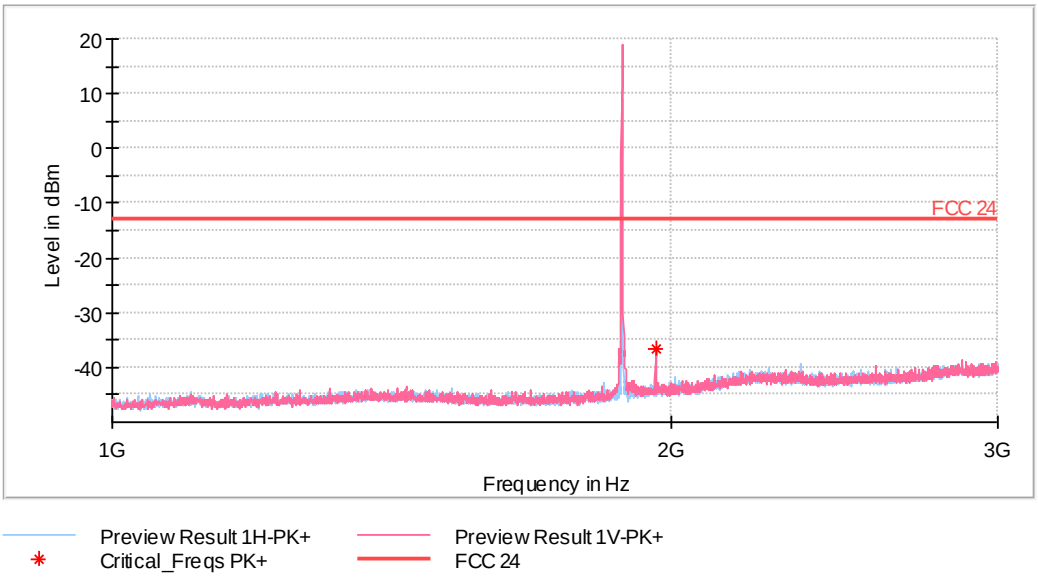
Frequency range 1 GHz to 3 GHz

CHANNEL: LOWEST



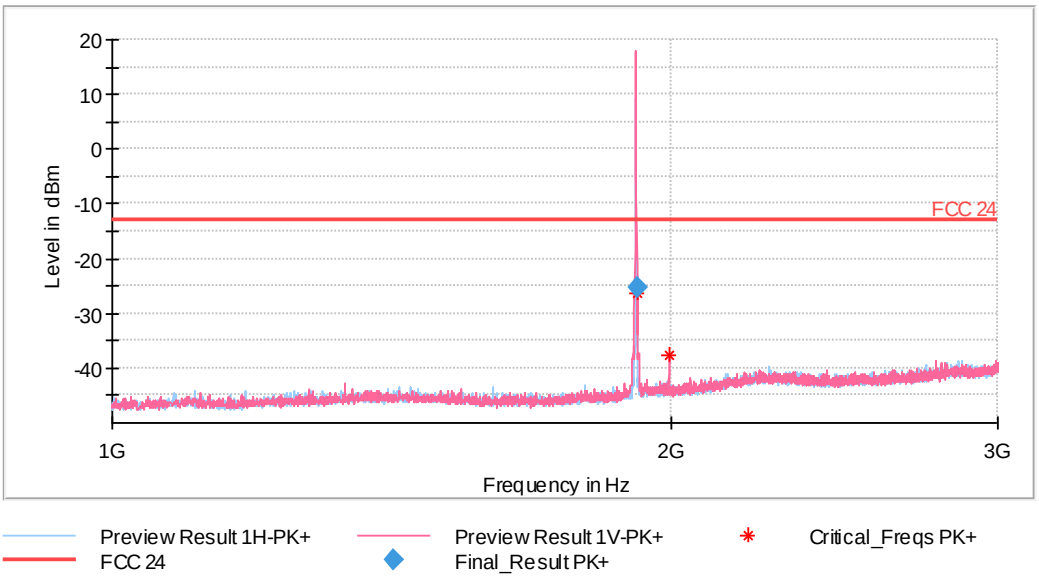
Note: The peak above the limit is the carrier frequency. The peak at 1930MHz corresponds to the downlink signal

CHANNEL: MIDDLE



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

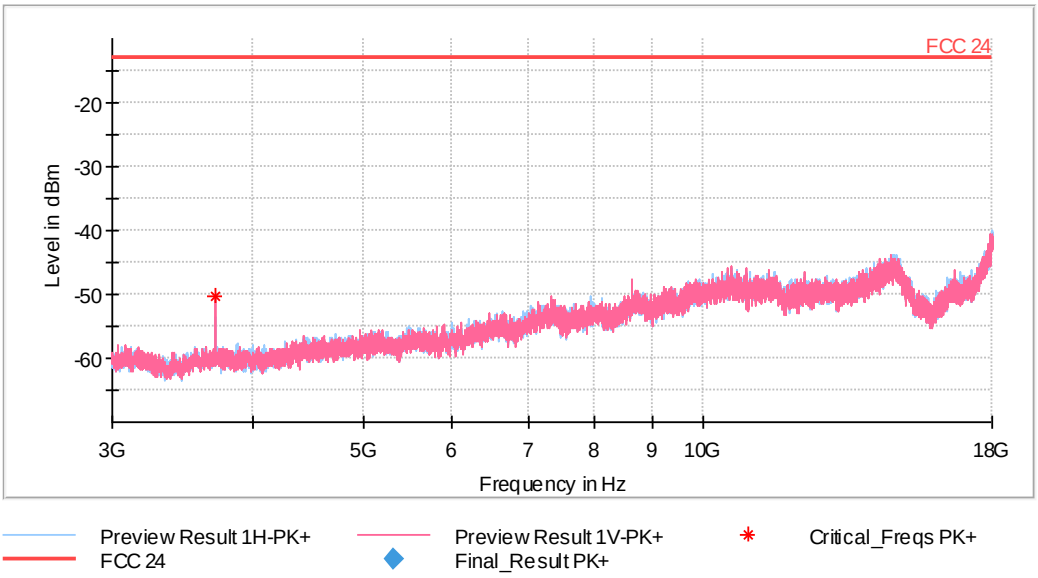
CHANNEL: HIGHEST



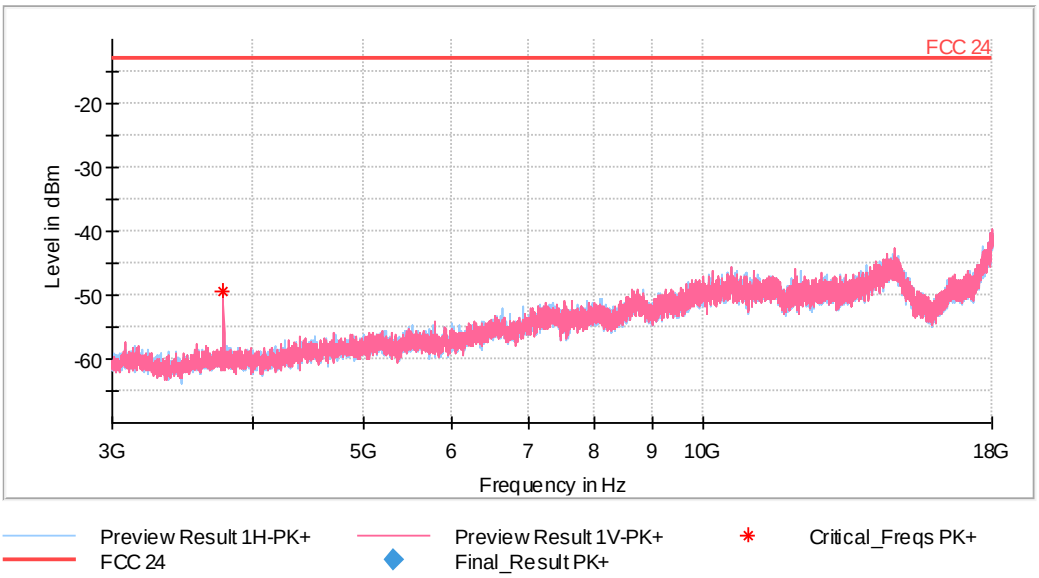
Note: The peak above the limit is the carrier frequency. The peak at 1995MHz corresponds to the downlink signal

Frequency range 3 GHz to 18 GHz

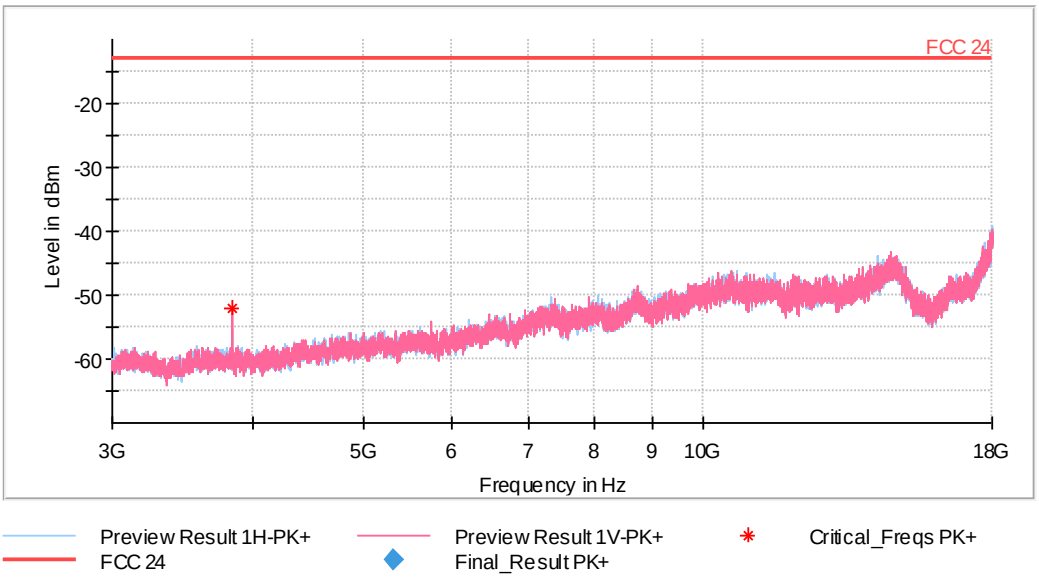
CHANNEL: LOWEST



CHANNEL: MIDDLE

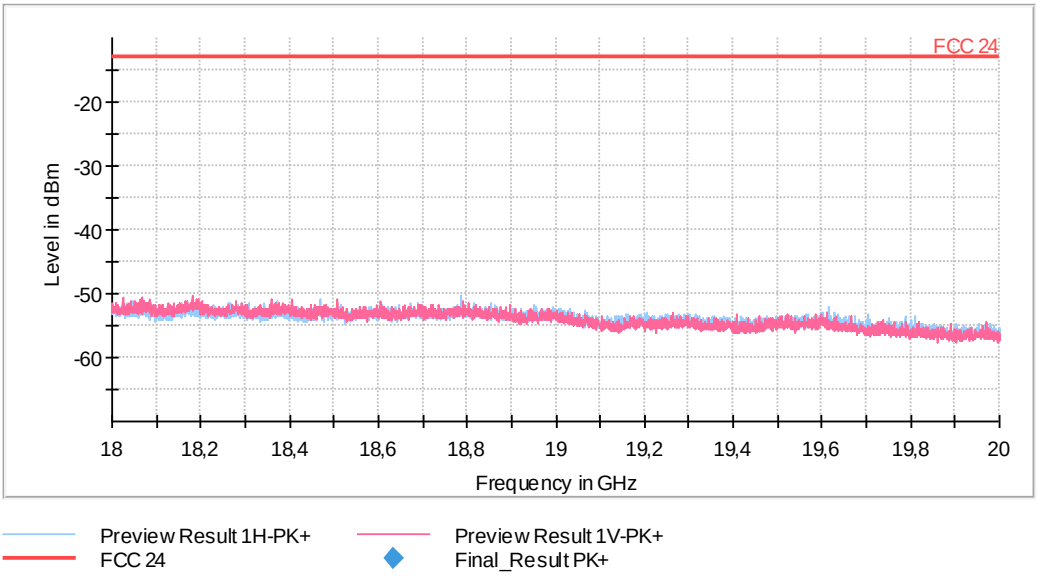


CHANNEL: HIGHEST

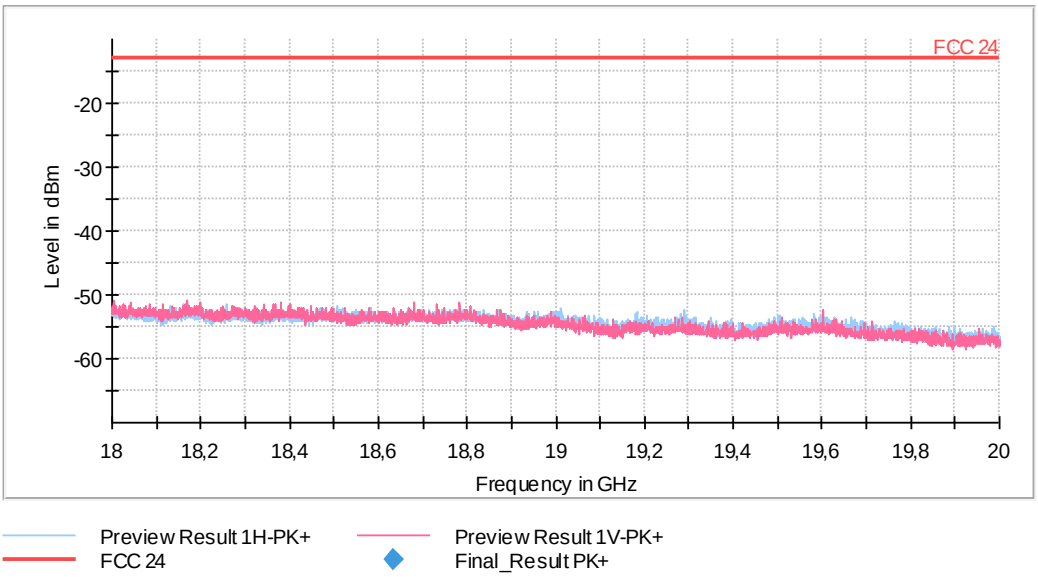


Frequency range 18 GHz to 20 GHz

CHANNEL: LOWEST



CHANNEL: MIDDLE



CHANNEL: HIGHEST