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.001A2

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 1, Oct. 2013. CANADA RSS-132 Issue 3, Jan. 2013. CANADA RSS-133 Issue 6, Jan. 2013. 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)	Jose Carlos Luque RF Lab. Supervisor Firmado digitalmente por 74841983Y JOSE CARLOS LUQUE (C:A29507456) Fecha: 2021.07.22 08:44:32 +02'00'
Date of issue	2021-07-22
Report template No	FDT08_23 (*) "Data provided by the client"

Index

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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.

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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

Ports…… :	Port name and description	Cable					
		Specified max length [m]	Attached during test	Shielded	Coupled to patient(3)		
	---		[ ]	[ ]	[ ]		
Supplementary information to the ports…… :	---						
Rated power supply .....:	Voltage and Frequency			Reference poles			
				L1	L2	L3	N	PE
	[ ]	AC:		[ ]	[ ]	[ ]	[ ]	[ ]
	[X]	DC: 3.2– 4.2VDC (typ 3.8 VDC)						
Rated Power .....:	23 dBm						
Clock frequencies.....:	Clock 26MHz, XTAL 32.768kHz						
Other parameters .....:	-30°C to + 70°C						
Software version .....:	M0P.000001						
Hardware version .....:	1.0						
Dimensions in cm (W x H x D) ....:	13.1 x 14.3 mm						
Mounting position .....:	[ ]	Table top equipment					
	[ ]	Wall/Ceiling mounted equipment					
	[ ]	Floor standing equipment					
	[ ]	Hand-held equipment					
	[X]	Other: solder down on host equipment					
Modules/parts.....:	Module/parts of test item		Type	Manufacturer			
	None, the device is module itself						
Accessories (not part of the test item) .....:	Description		Type	Manufacturer			
	Antenna only for testing purposed		T-AT305	ATEL-CAB			
Documents as provided by the applicant.....:	Description		File name	Issue date			
	---						

(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.

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. = 35 %
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 4.4.: RF output power	P	
Clause 2.1047 / RSS-139 Clause 6.2. / RSS-130 Clause 4.1.: Modulation characteristics	P	
Clause 27.54 / RSS-139 Clause 6.4. / RSS-130 Clause 4.3.: Frequency stability	P	
Clause 2.1049: Occupied Bandwidth	P	
Clause 27.53 / RSS-139 Clause 6.6. / RSS-130 Clause 4.6.: Spurious emissions at antenna terminals	P	
Clause 27.53 / RSS-139 Clause 6.6. / RSS-130 Clause 4.6.: Radiated emissions	P	
Supplementary information and remarks: (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:

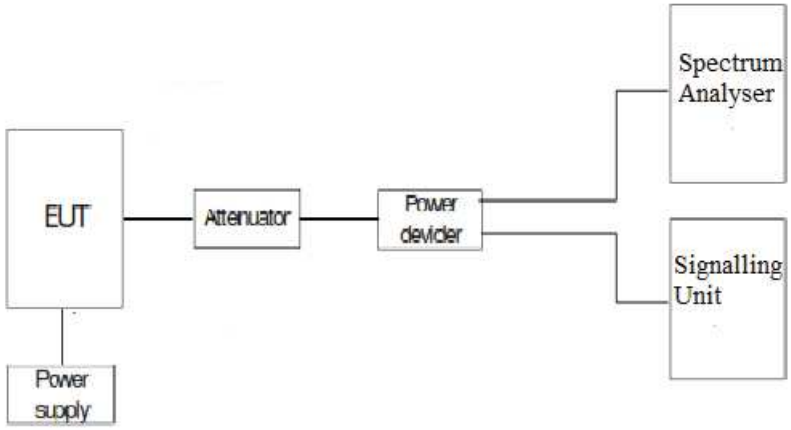
E.R.P. = E.I.R.P. – 2.15 dB

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.

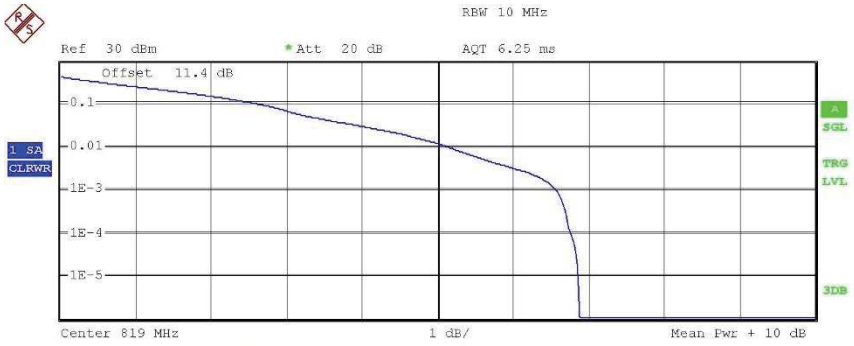
Preliminary measurements determined that 12 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

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
NOF 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
NOF 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.

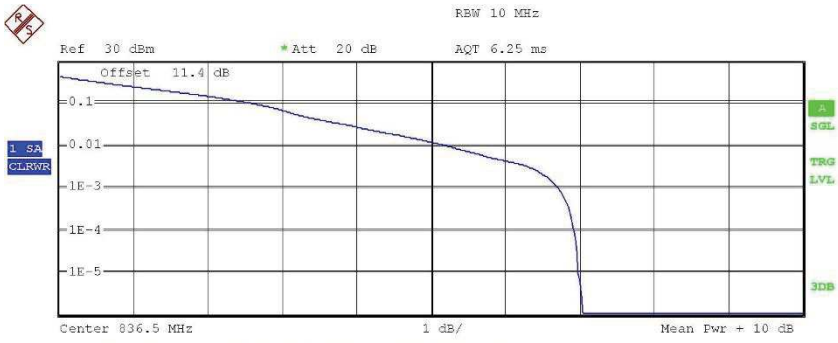
Preliminary measurements determined that 12 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

Channel Low:

Complementary Cumulative Distribution Function
NOF 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
NOF 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

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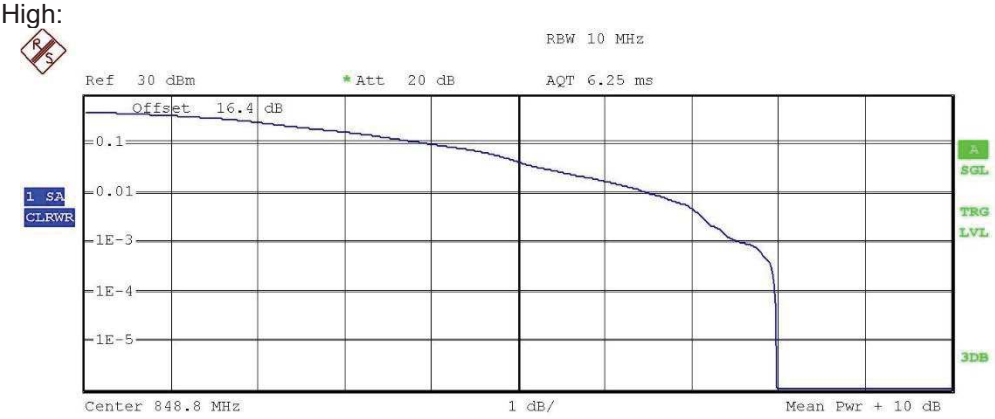
Channel High:



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.

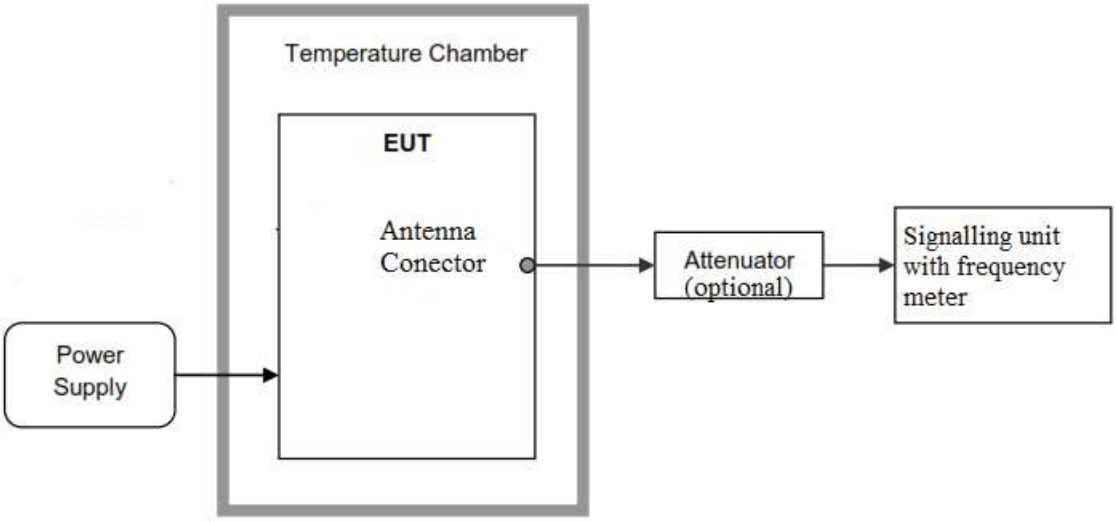
The EUT was set in “Radio Resource Control (RRC) mode” in the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case LTE mode for conducted power was used for the test.

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.

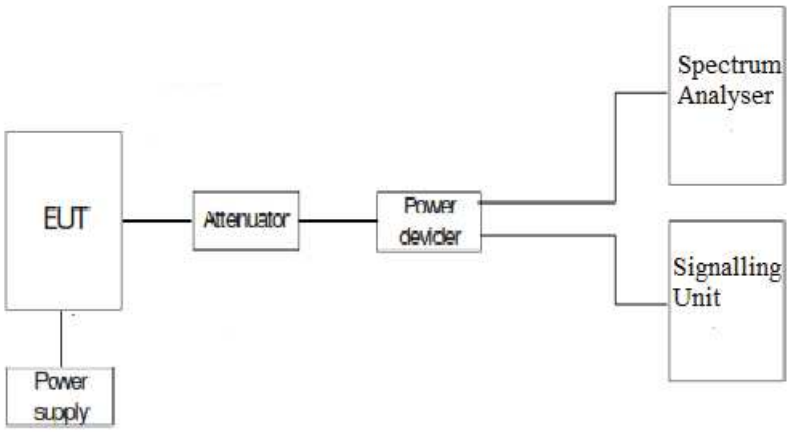
The reference point measurements were made at the RF output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

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

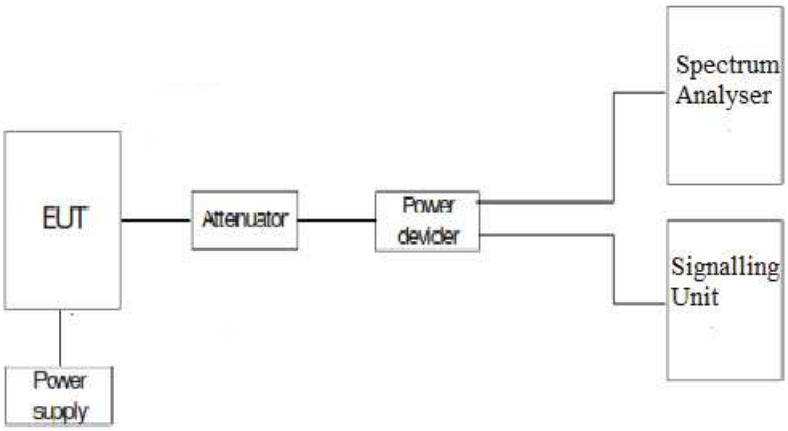
SPECIFICATION
FCC §2.1047.

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.

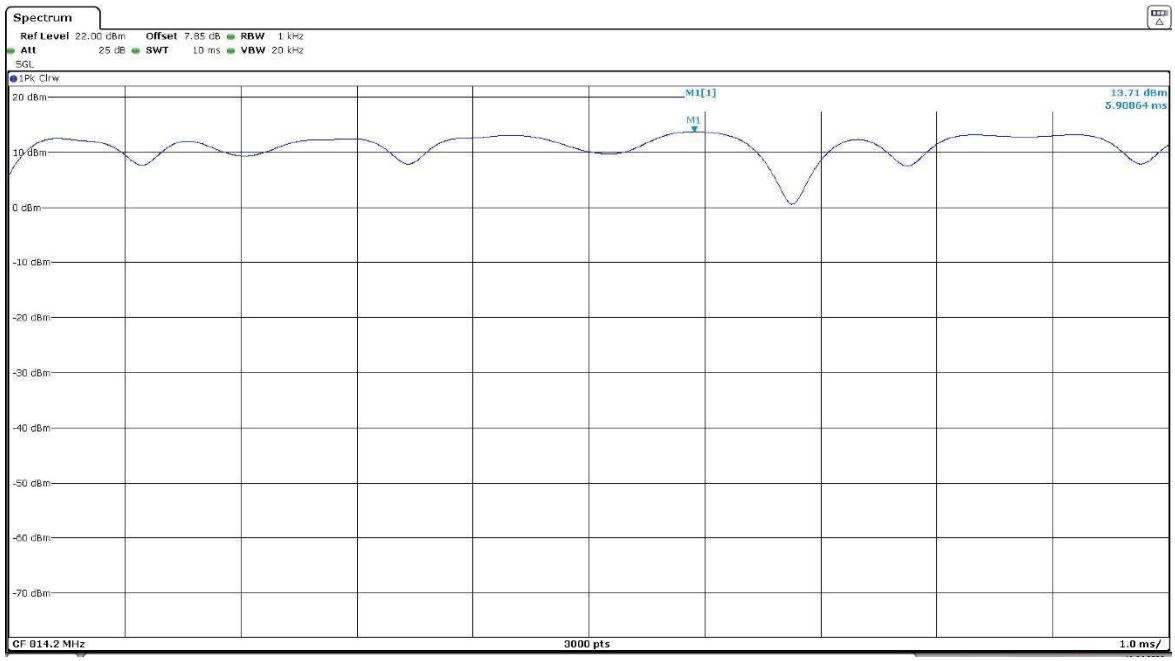
TEST SETUP



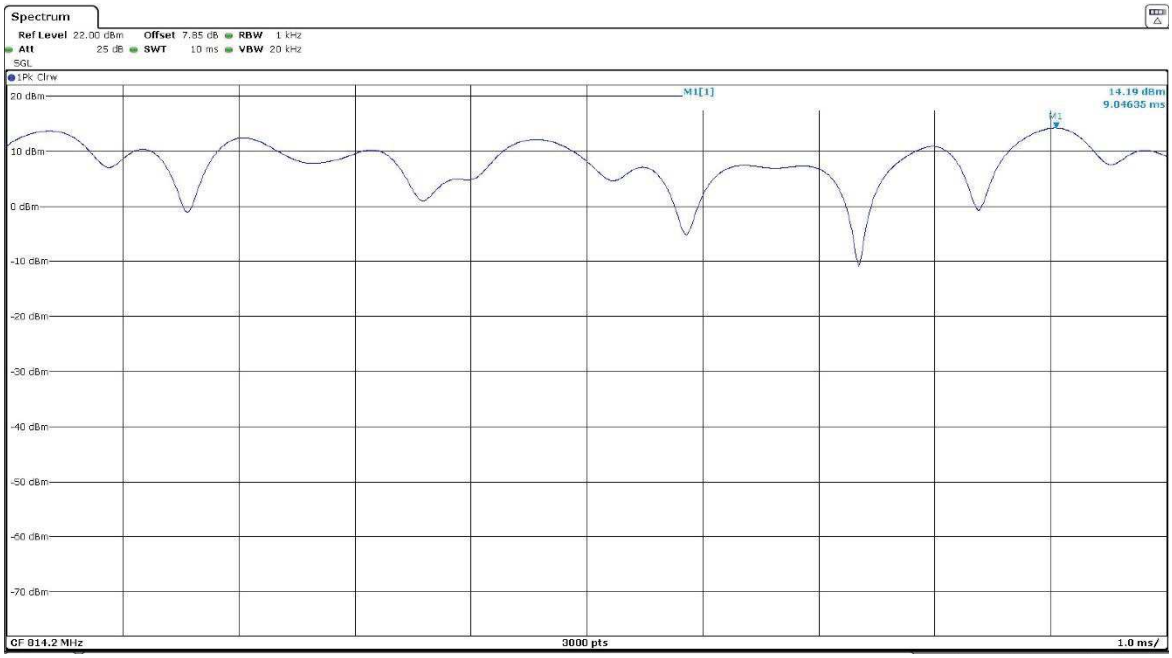
RESULTS

The following plot shows the modulation schemes in the EUT.

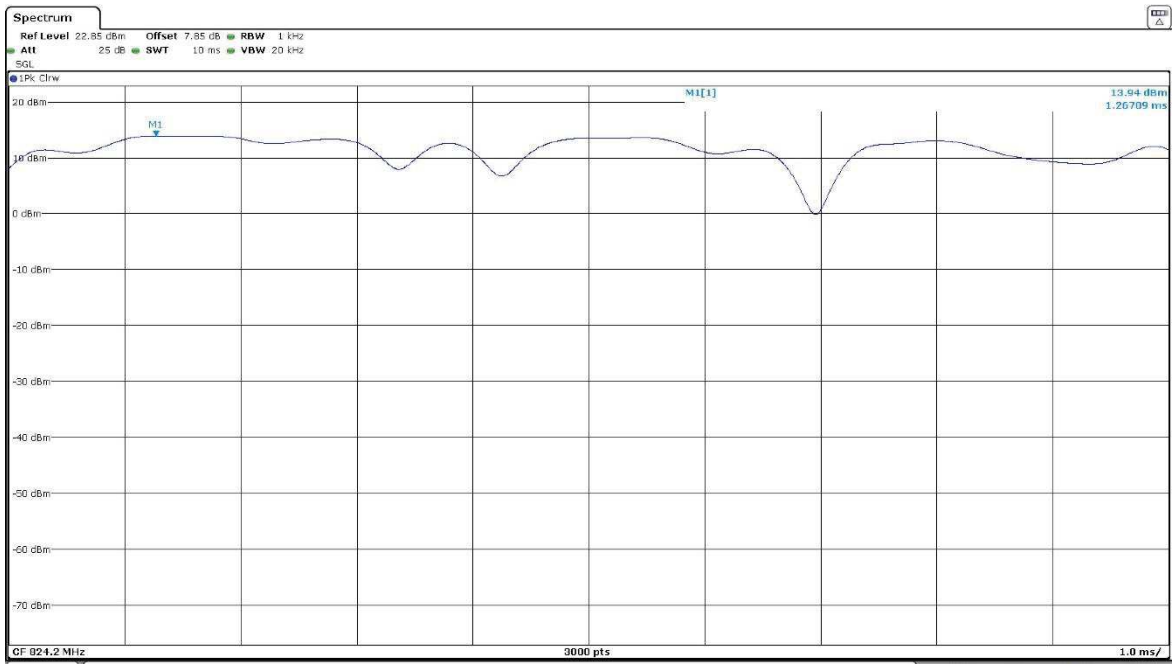
NBIoT MODULATION (Band 26). π/2 - BPSK.



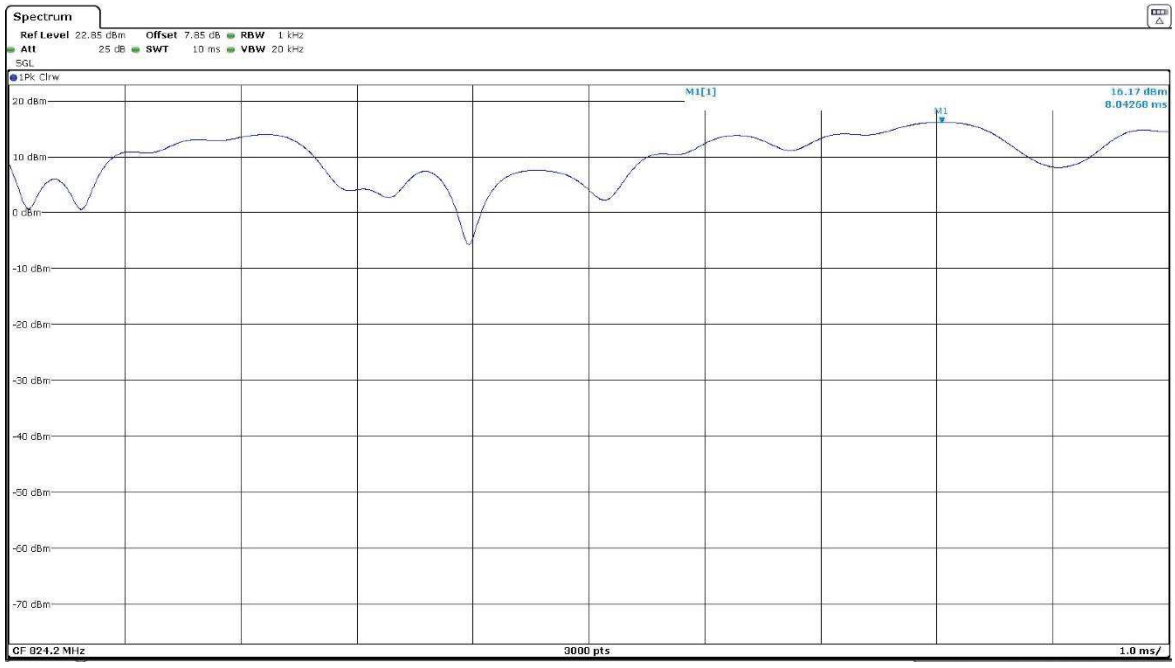
NBIoT MODULATION (Band 26). π/4 - QPSK.



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



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



Occupied Bandwidth

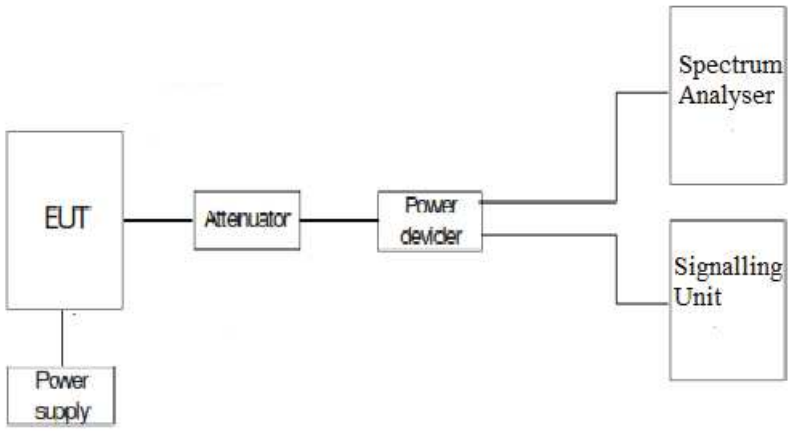
SPECIFICATION

§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		

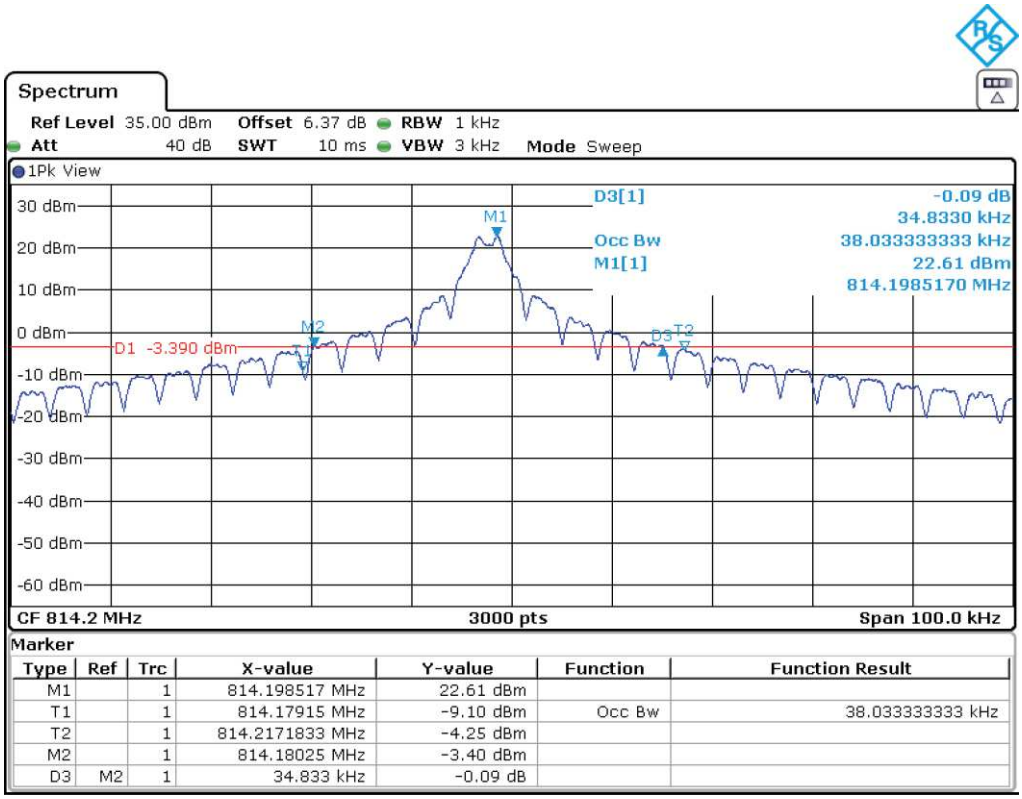
12 Tones 15 kHz. π/4 - QPSK MODULATION

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

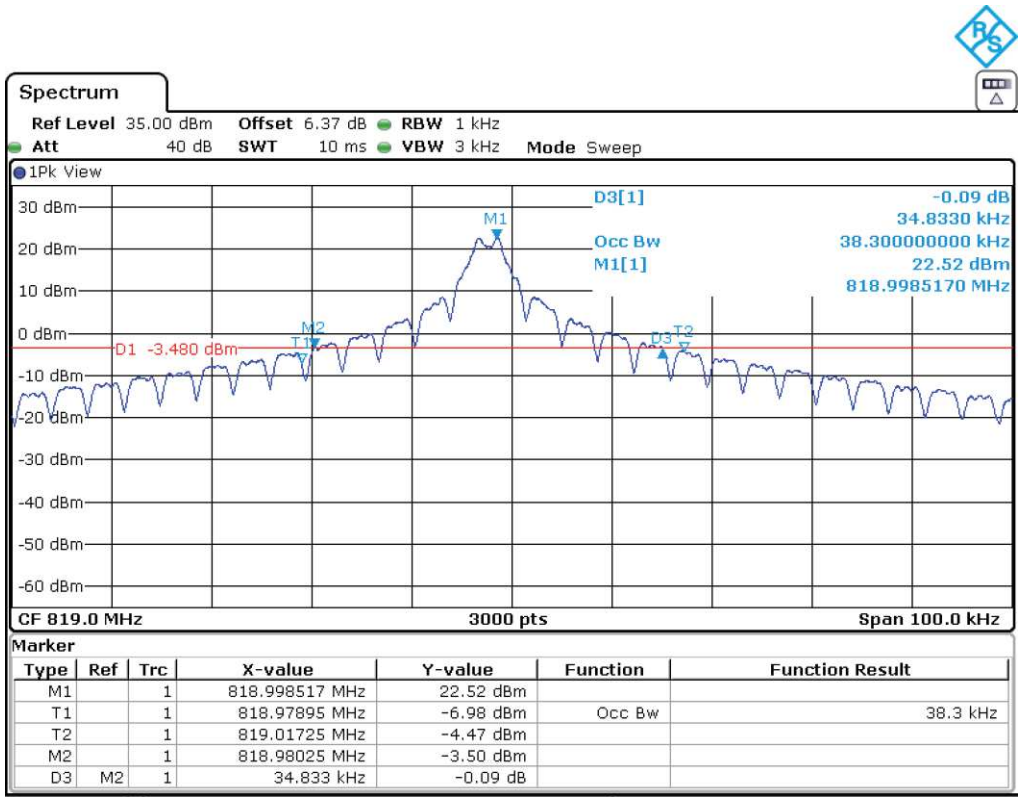
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	814.198517 MHz	22.61 dBm		
T1		1	814.17915 MHz	-9.10 dBm	Occ Bw	38.033333333 kHz
T2		1	814.2171833 MHz	-4.25 dBm		
M2		1	814.18025 MHz	-3.40 dBm		
D3	M2	1	34.833 kHz	-0.09 dB		

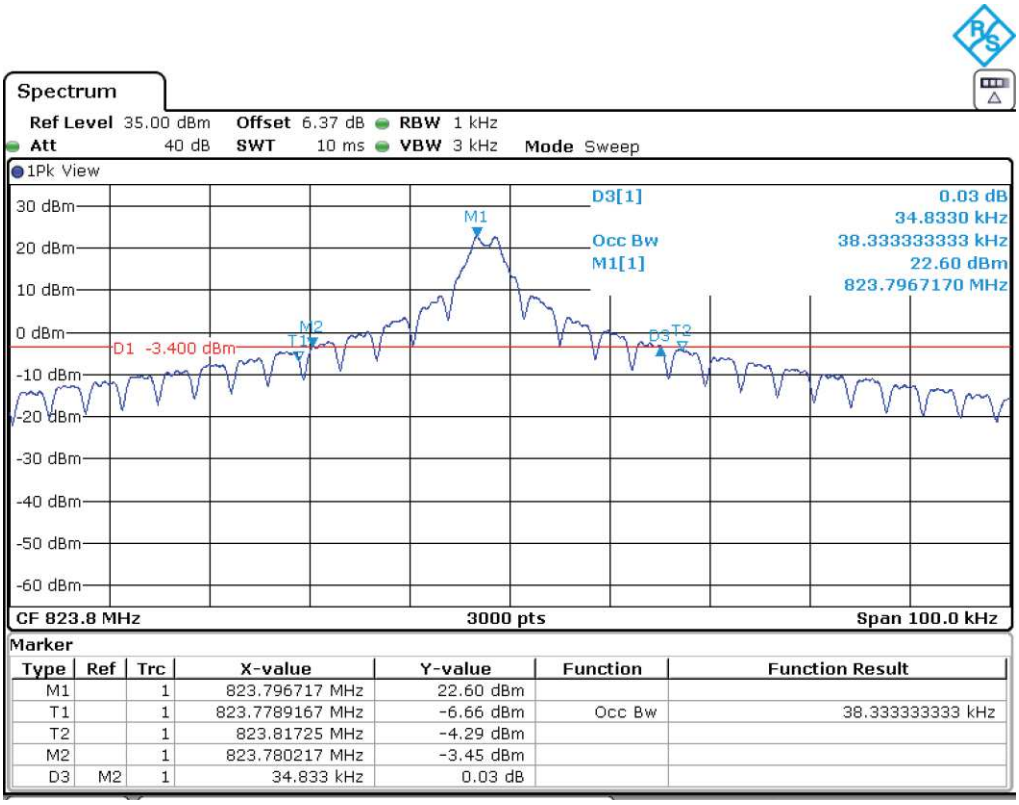
Middle Channel



Marker

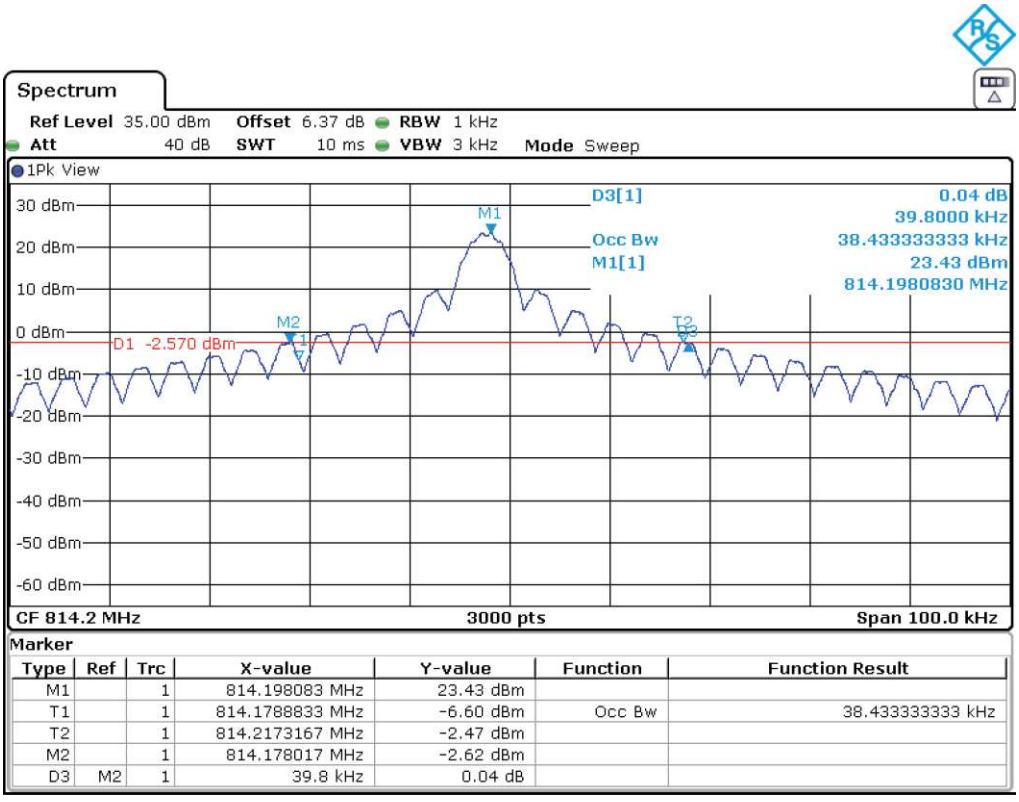
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	818.998517 MHz	22.52 dBm		
T1		1	818.97895 MHz	-6.98 dBm	Occ Bw	38.3 kHz
T2		1	819.01725 MHz	-4.47 dBm		
M2		1	818.98025 MHz	-3.50 dBm		
D3	M2	1	34.833 kHz	-0.09 dB		

Highest Channel

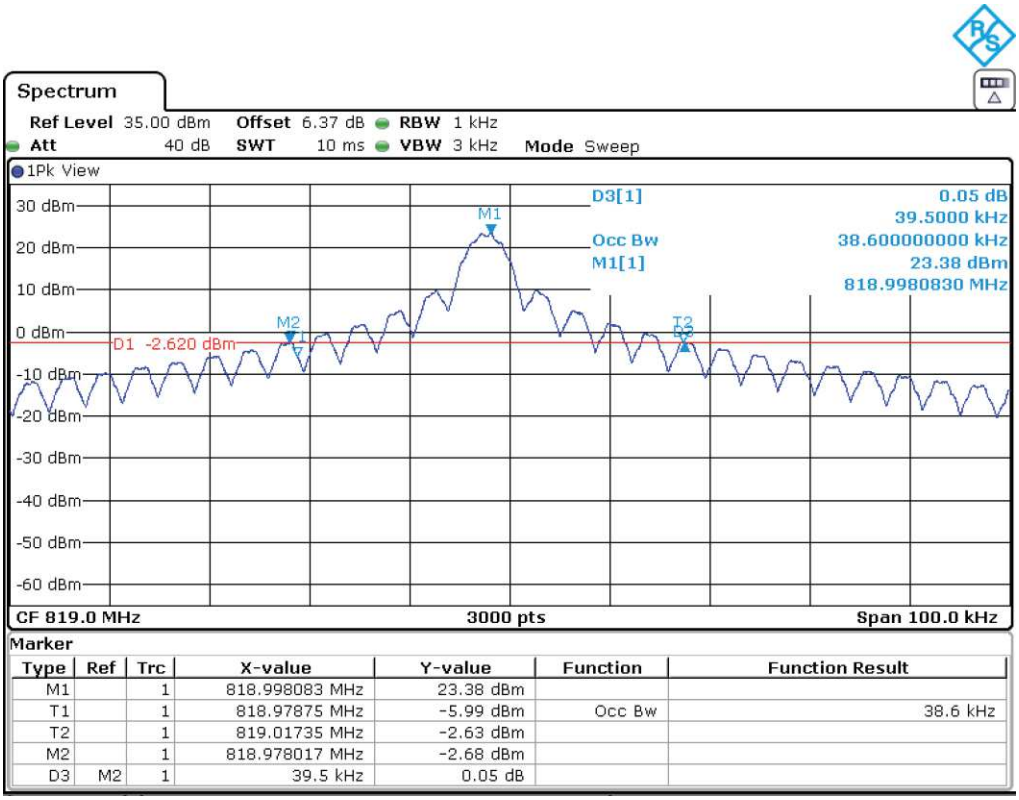


Tone 3.75 kHz. π/4 - QPSK MODULATION

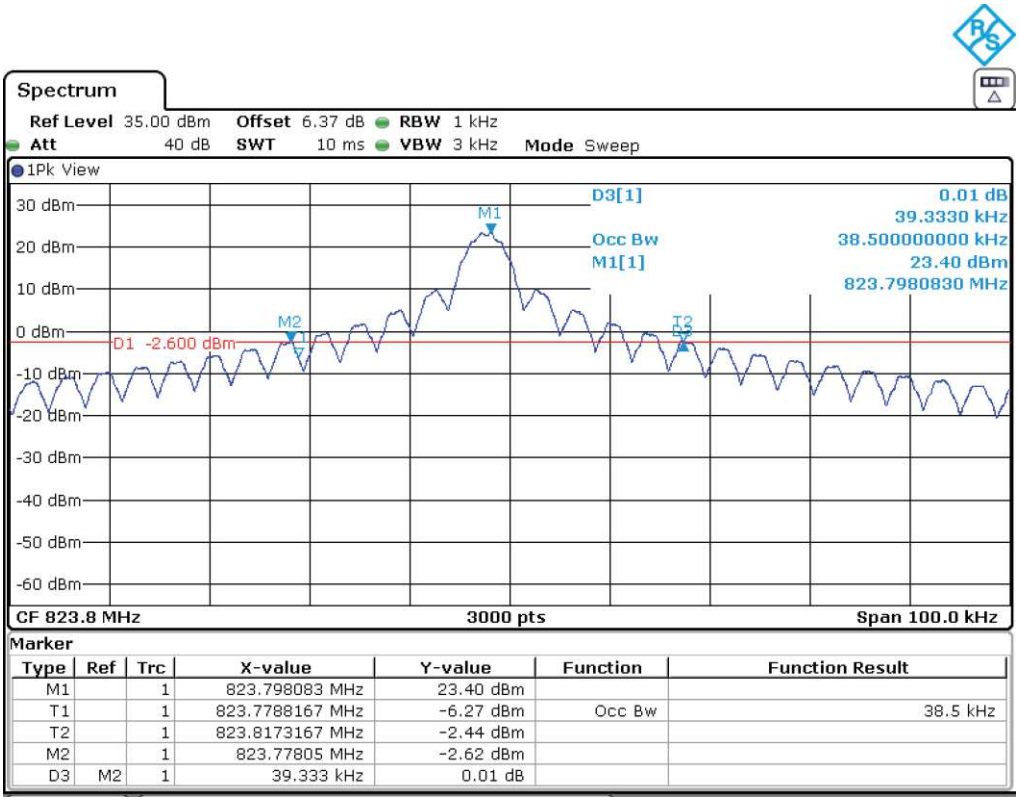
Lowest Channel



Middle Channel

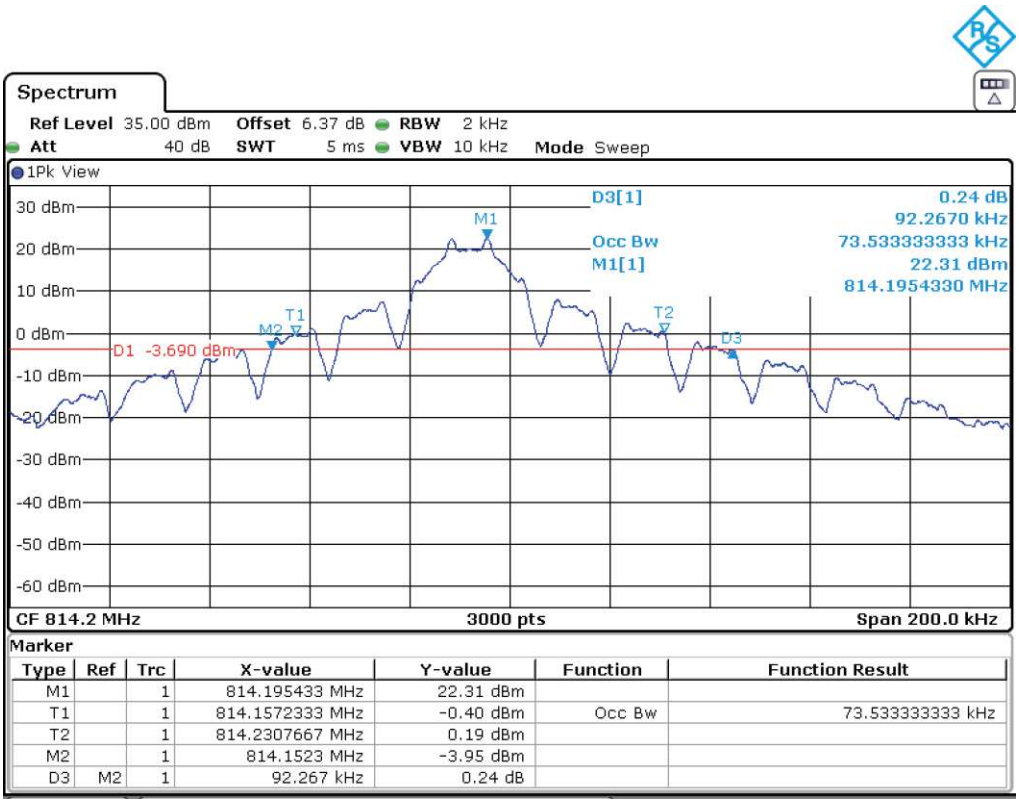


Highest Channel



Tone 15 kHz. π/2 - BPSK MODULATION

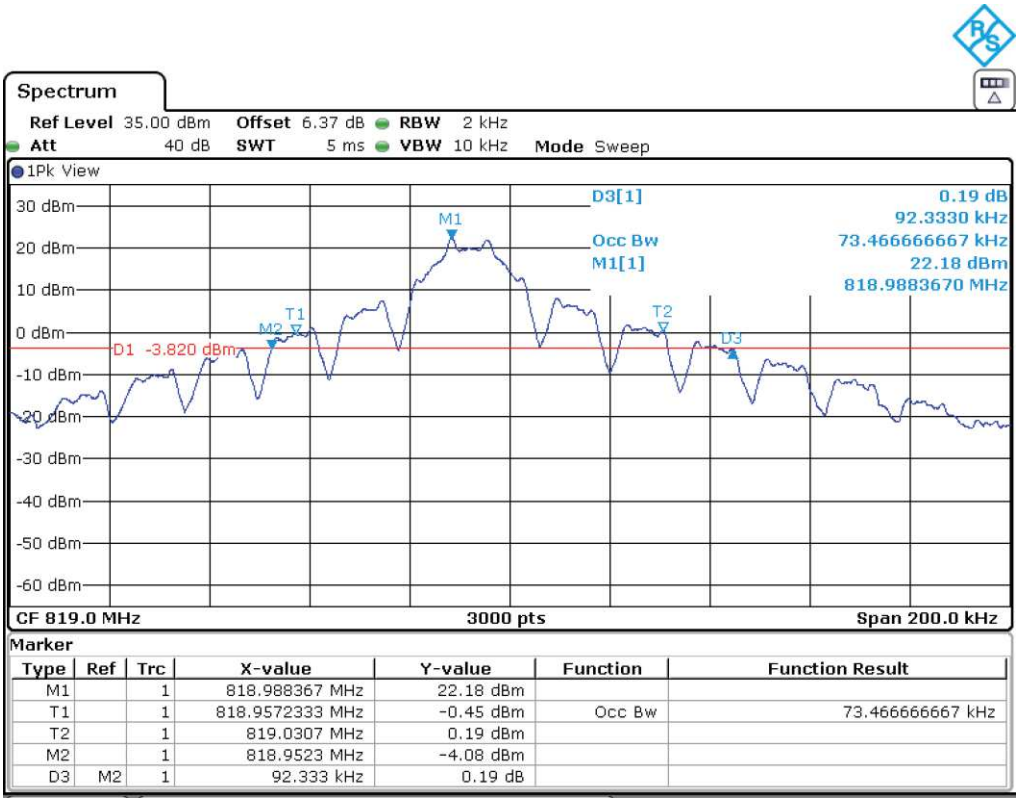
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	814.195433 MHz	22.31 dBm		
T1		1	814.1572333 MHz	-0.40 dBm	Occ Bw	73.533333333 kHz
T2		1	814.2307667 MHz	0.19 dBm		
M2		1	814.1523 MHz	-3.95 dBm		
D3	M2	1	92.267 kHz	0.24 dB		

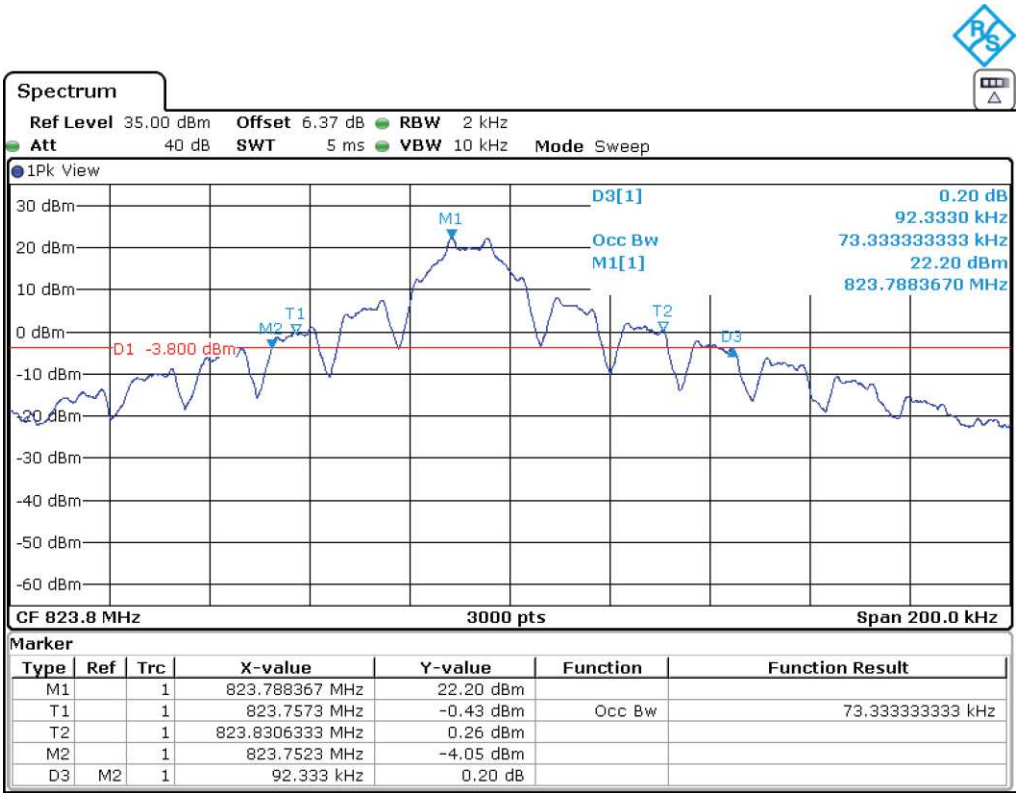
Middle Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	818.988367 MHz	22.18 dBm		
T1		1	818.9572333 MHz	-0.45 dBm	Occ Bw	73.466666667 kHz
T2		1	819.0307 MHz	0.19 dBm		
M2		1	818.9523 MHz	-4.08 dBm		
D3	M2	1	92.333 kHz	0.19 dB		

Highest Channel

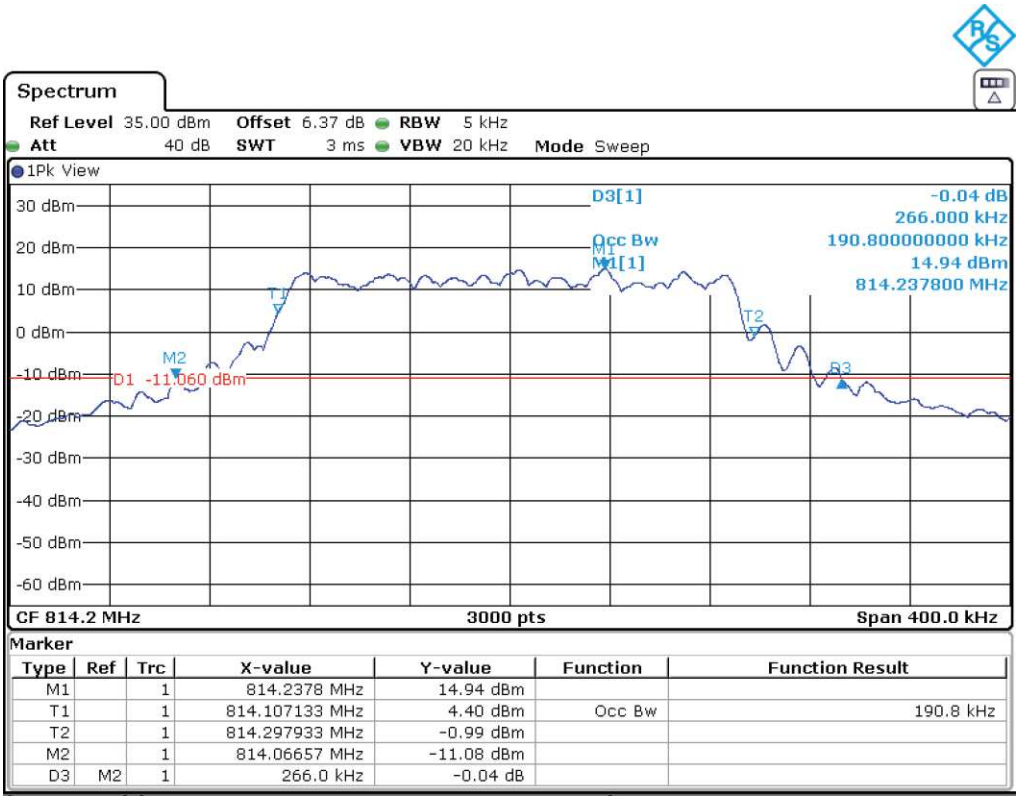


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	823.788367 MHz	22.20 dBm		
T1		1	823.7573 MHz	-0.43 dBm	Occ Bw	73.333333333 kHz
T2		1	823.8306333 MHz	0.26 dBm		
M2		1	823.7523 MHz	-4.05 dBm		
D3	M2	1	92.333 kHz	0.20 dB		

12 Tones 15 kHz. π/4 - QPSK MODULATION

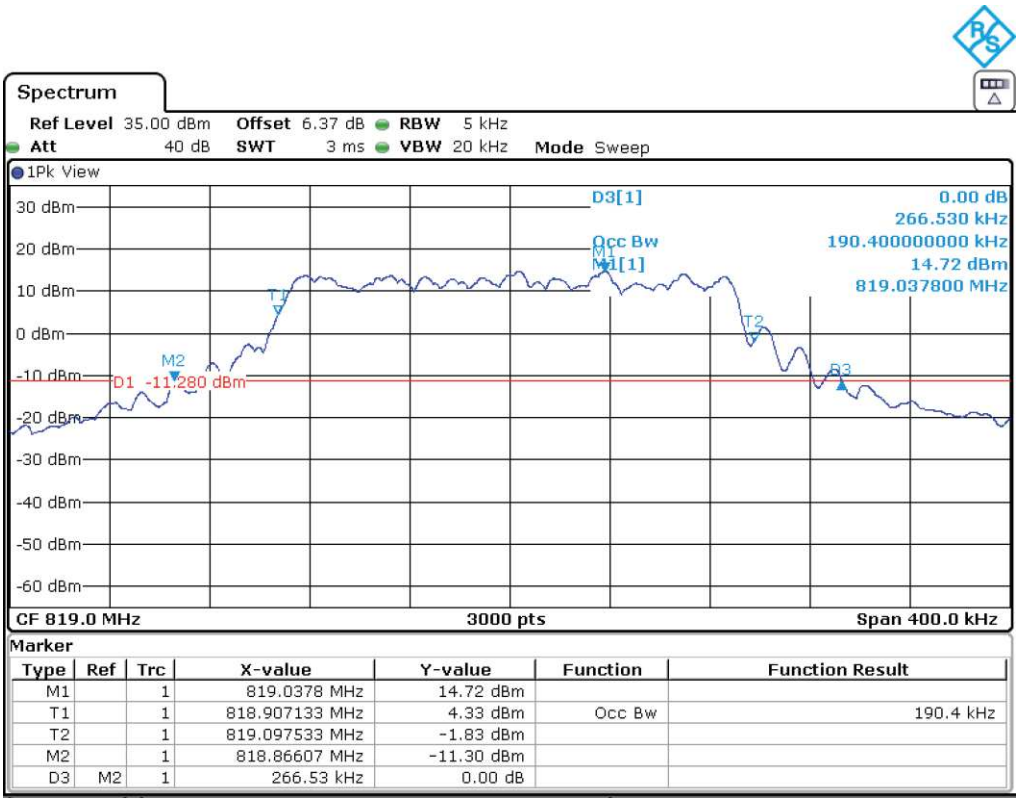
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	814.2378 MHz	14.94 dBm		
T1		1	814.107133 MHz	4.40 dBm	Occ Bw	190.8 kHz
T2		1	814.297933 MHz	-0.99 dBm		
M2		1	814.06657 MHz	-11.08 dBm		
D3	M2	1	266.0 kHz	-0.04 dB		

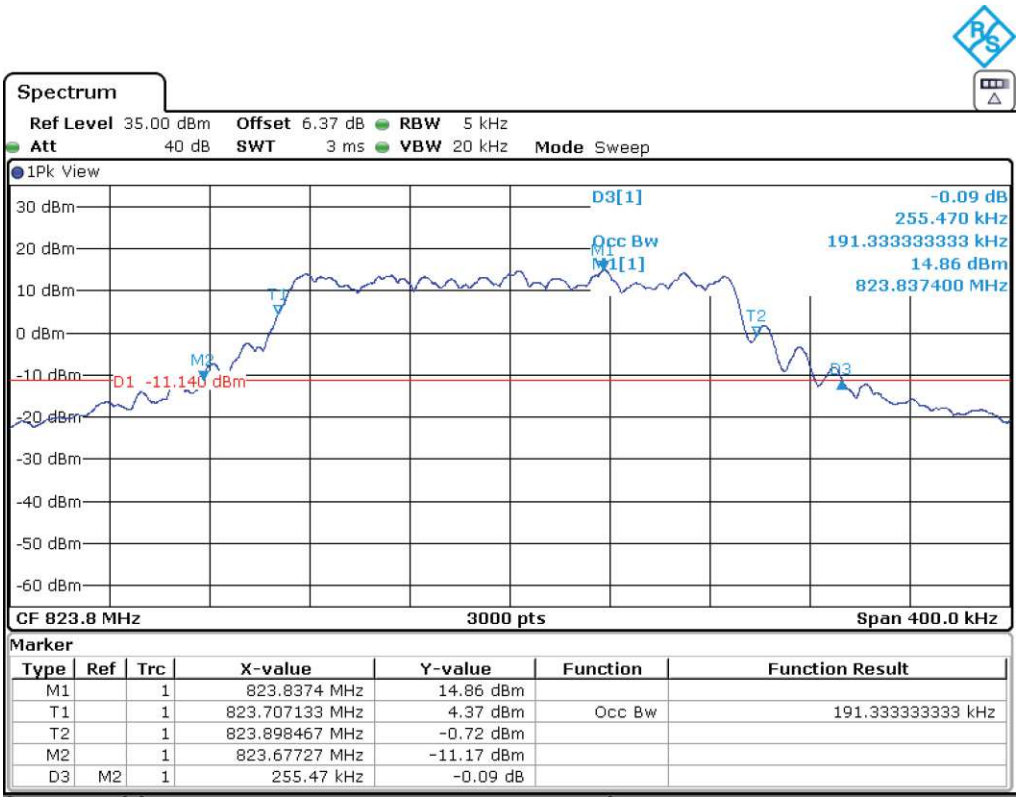
Middle Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	819.0378 MHz	14.72 dBm		
T1		1	818.907133 MHz	4.33 dBm	Occ Bw	190.4 kHz
T2		1	819.097533 MHz	-1.83 dBm		
M2		1	818.86607 MHz	-11.30 dBm		
D3	M2	1	266.53 kHz	0.00 dB		

Highest Channel



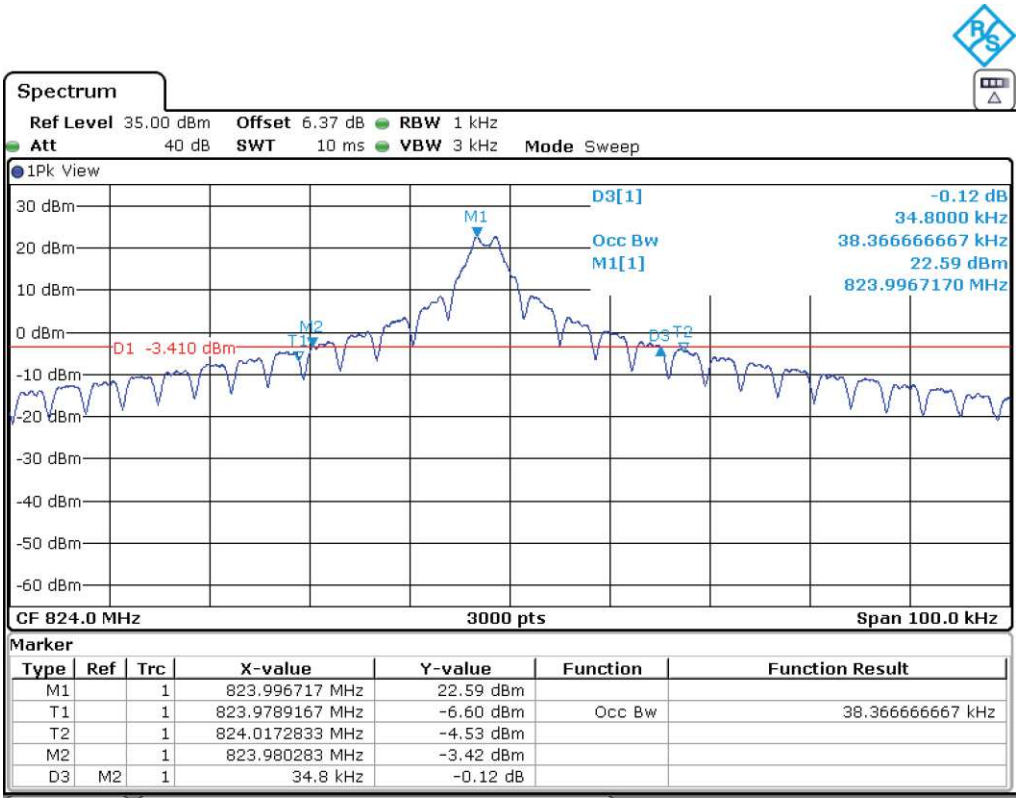
Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	823.8374 MHz	14.86 dBm		
T1		1	823.707133 MHz	4.37 dBm	Occ Bw	191.333333333 kHz
T2		1	823.898467 MHz	-0.72 dBm		
M2		1	823.67727 MHz	-11.17 dBm		
D3	M2	1	255.47 kHz	-0.09 dB		

NBIoT BAND 26.

NBIoT BAND 26 (824MHz).

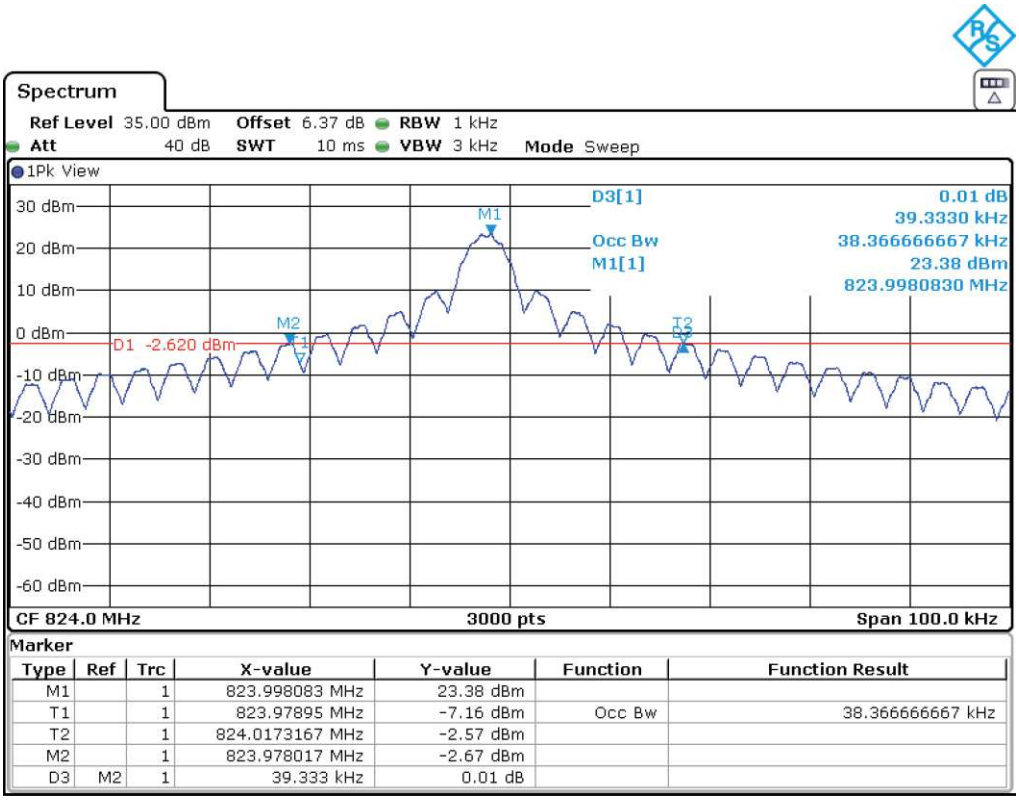
Tone 3.75 kHz. π/2 - BPSK MODULATION



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		

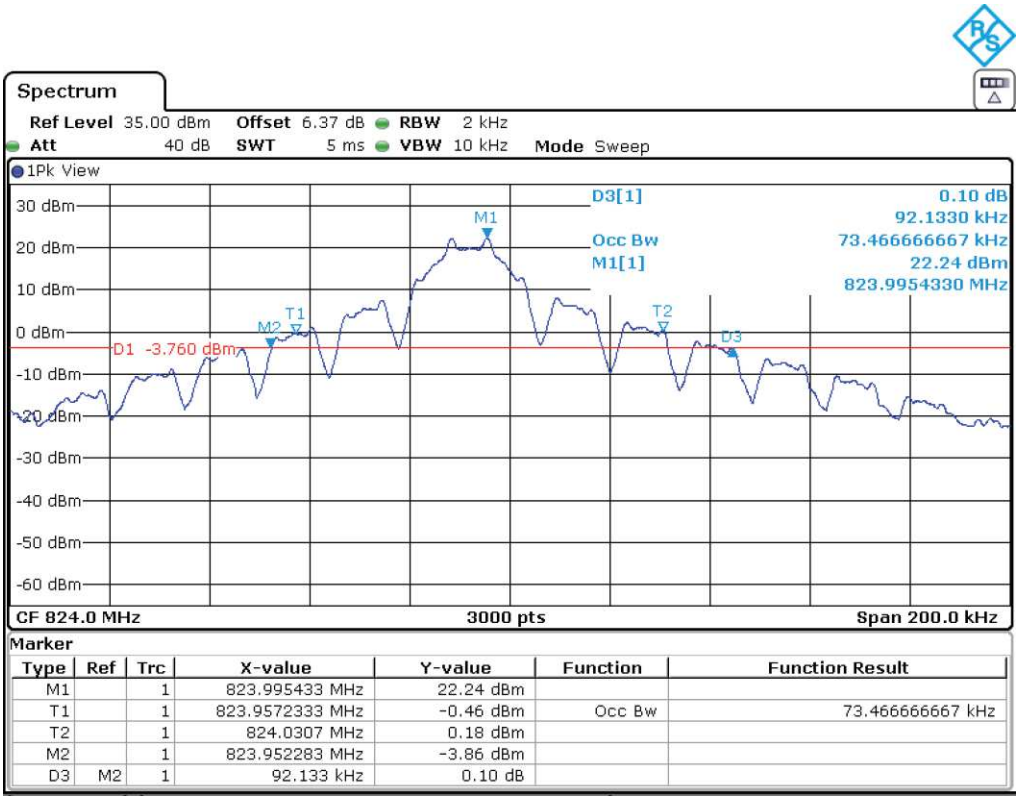
Tone 3.75 kHz. π/4 - QPSK MODULATION



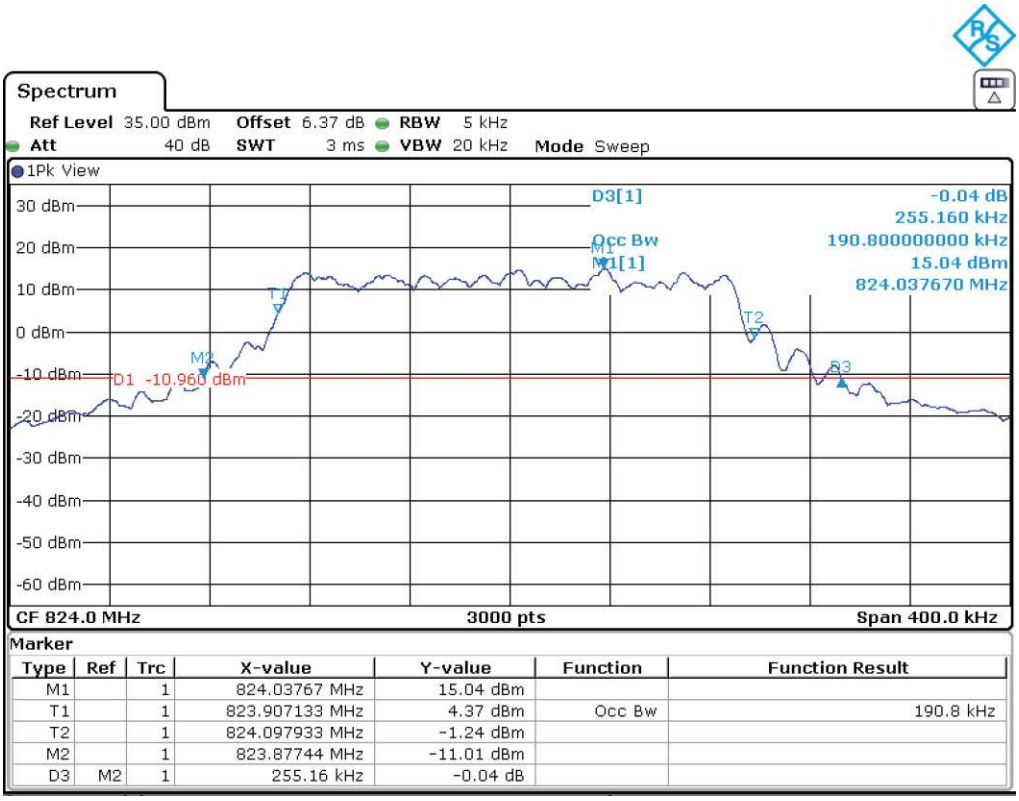
Marker

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



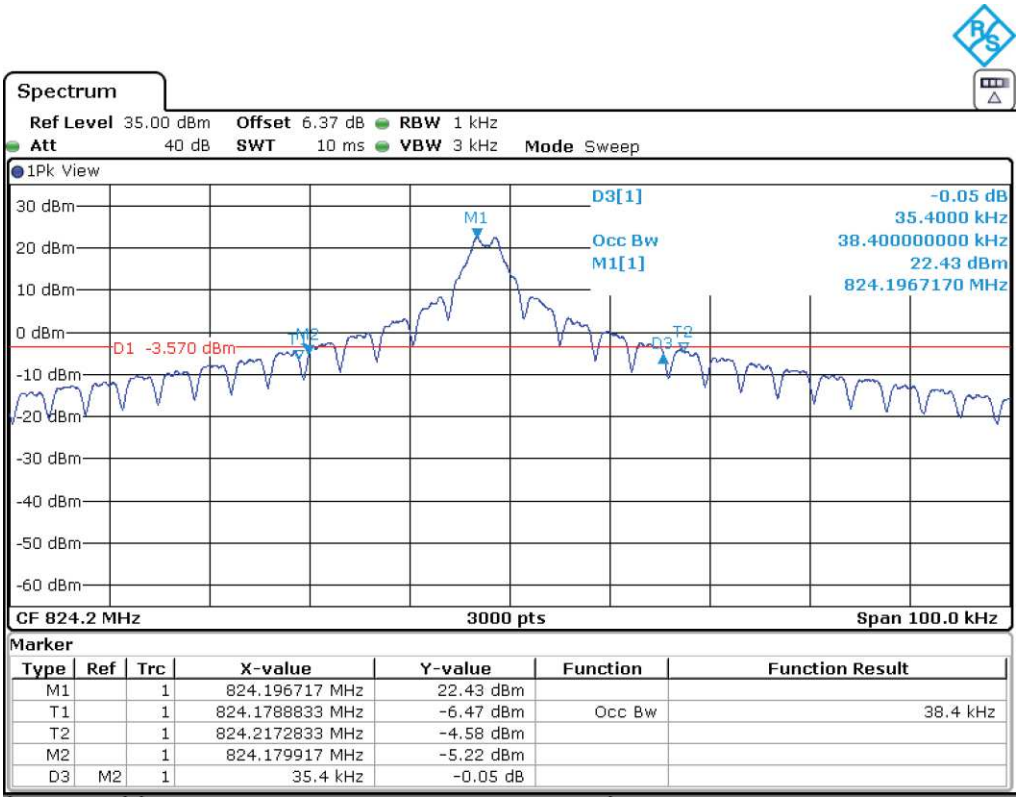
12 Tones 15 kHz. π/4 - QPSK MODULATION



NBIoT BAND 5.

Tone 3.75 kHz. π/2 - BPSK MODULATION

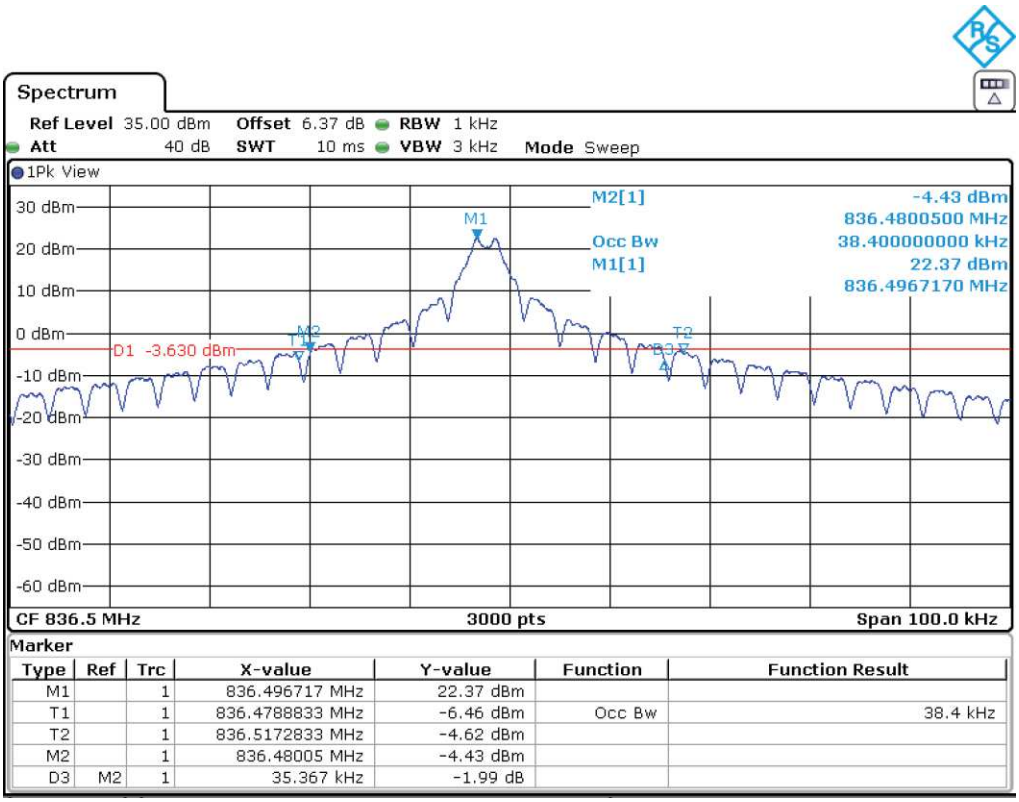
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	824.196717 MHz	22.43 dBm		
T1		1	824.1788833 MHz	-6.47 dBm	Occ Bw	38.4 kHz
T2		1	824.2172833 MHz	-4.58 dBm		
M2		1	824.179917 MHz	-5.22 dBm		
D3	M2	1	35.4 kHz	-0.05 dB		

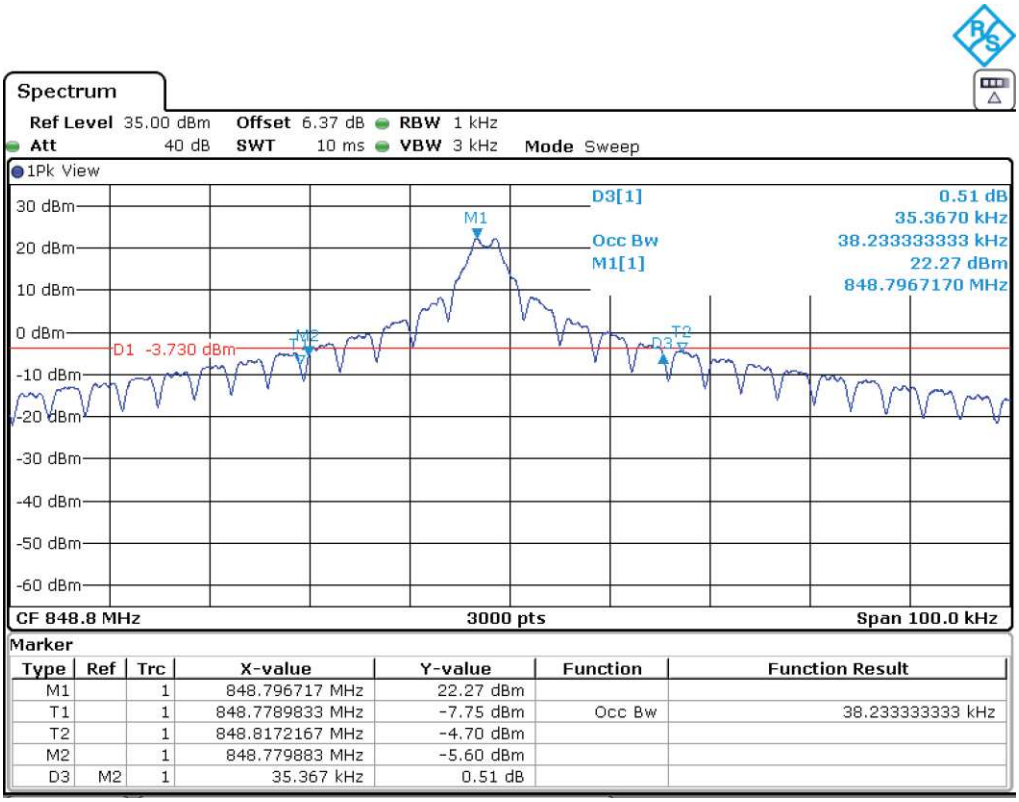
Middle Channel



Marker

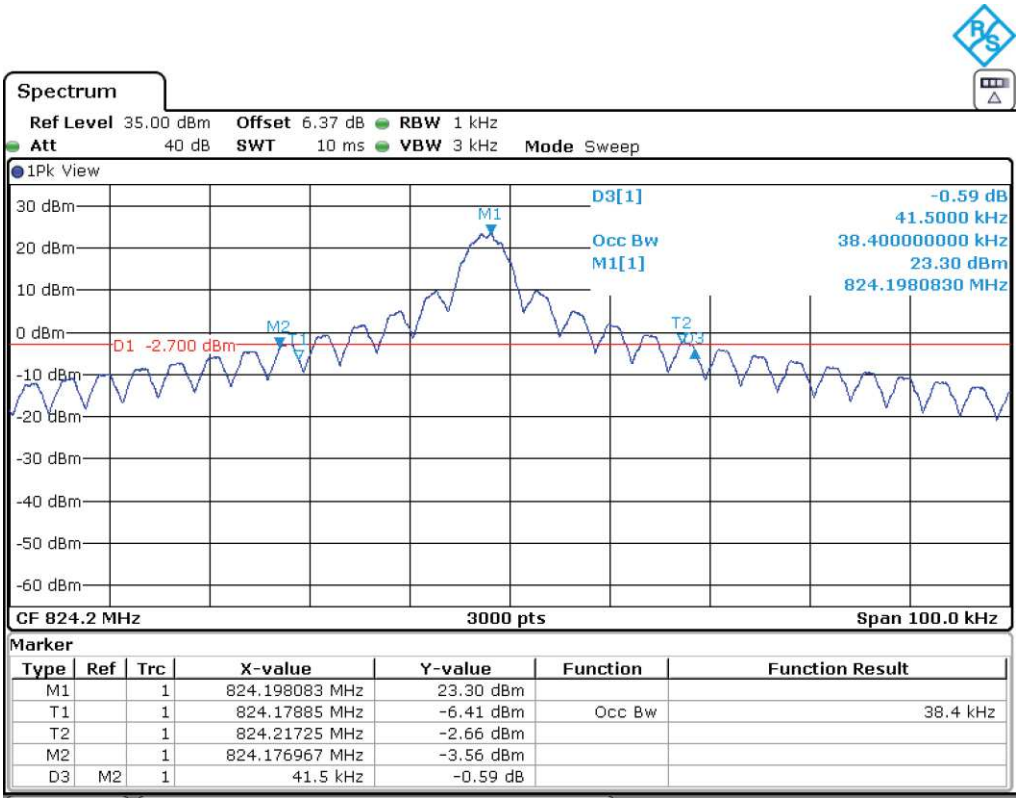
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	836.496717 MHz	22.37 dBm		
T1		1	836.4788833 MHz	-6.46 dBm	Occ Bw	38.4 kHz
T2		1	836.5172833 MHz	-4.62 dBm		
M2		1	836.48005 MHz	-4.43 dBm		
D3	M2	1	35.367 kHz	-1.99 dB		

Highest Channel

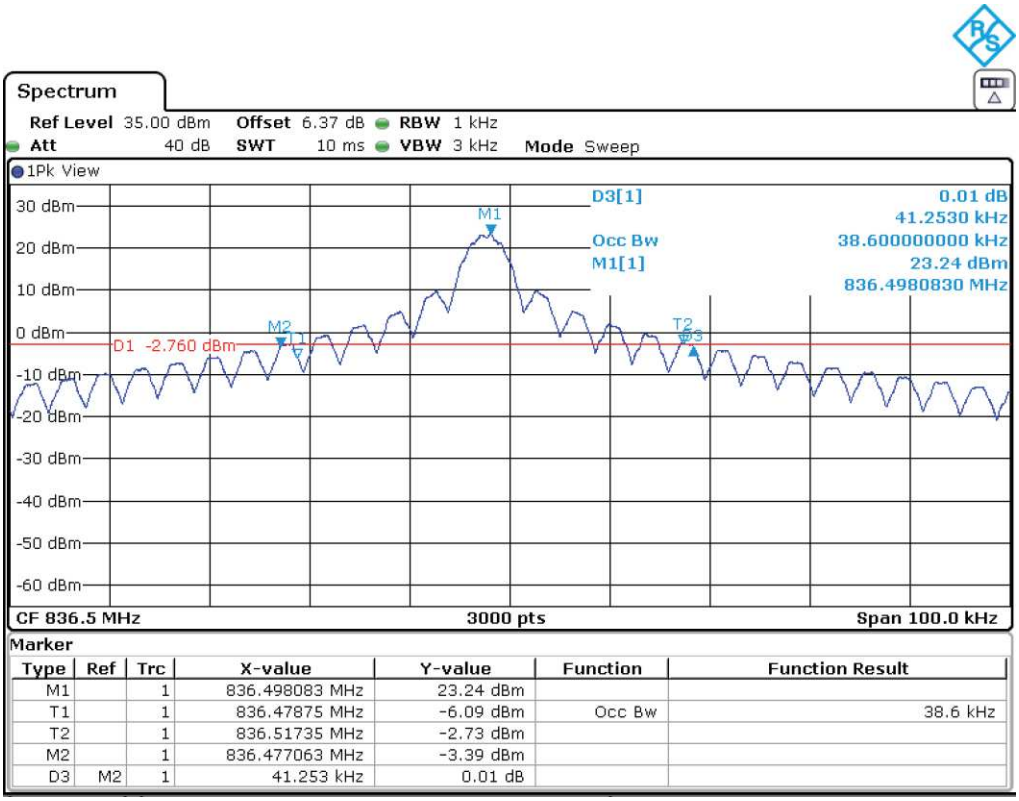


Tone 3.75 kHz. π/4 - QPSK MODULATION

Lowest Channel



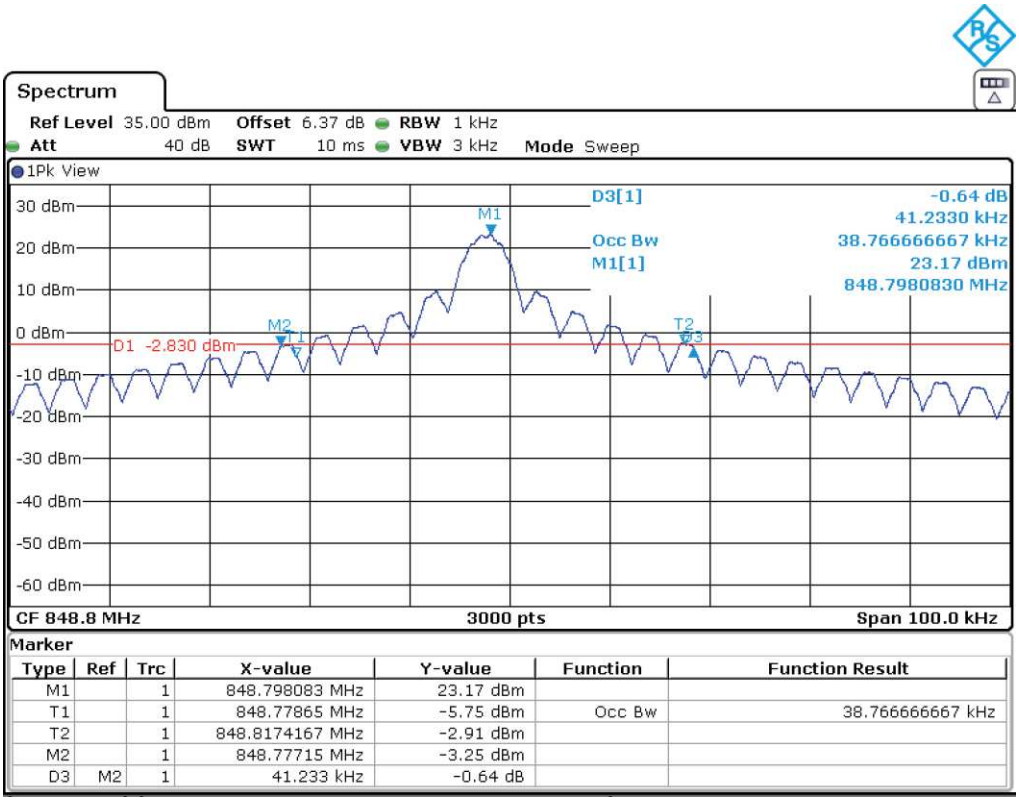
Middle Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	836.498083 MHz	23.24 dBm		
T1		1	836.47875 MHz	-6.09 dBm	Occ Bw	38.6 kHz
T2		1	836.51735 MHz	-2.73 dBm		
M2		1	836.477063 MHz	-3.39 dBm		
D3	M2	1	41.253 kHz	0.01 dB		

Highest Channel

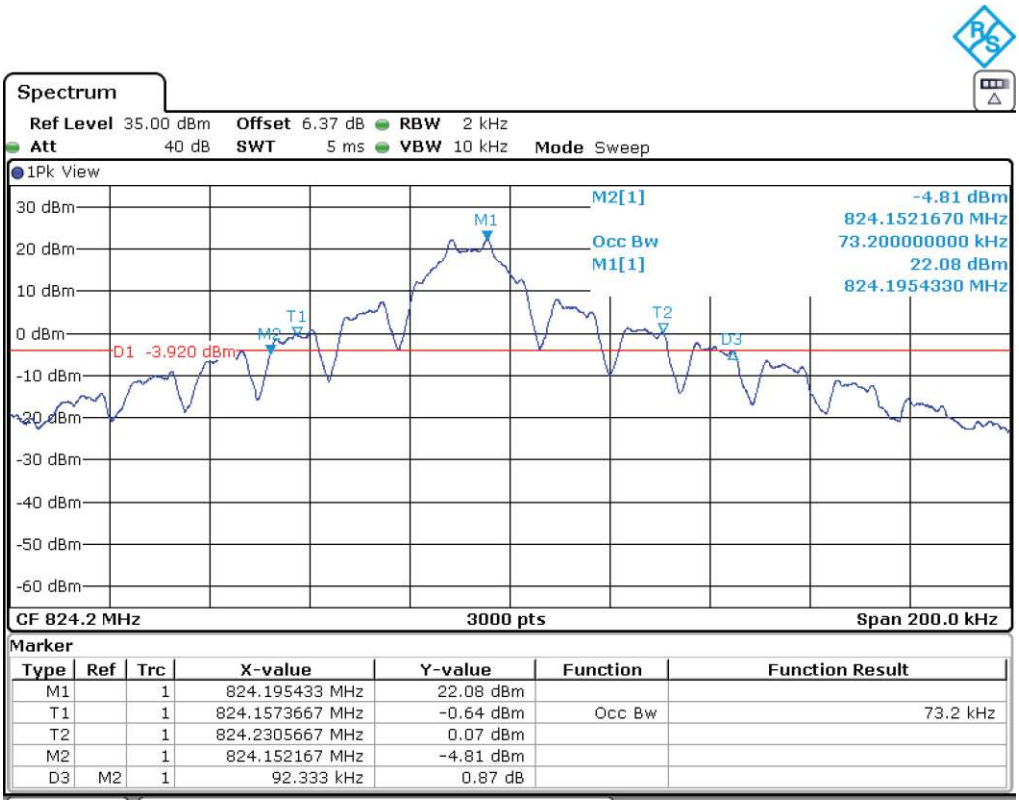


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	848.798083 MHz	23.17 dBm		
T1		1	848.77865 MHz	-5.75 dBm	Occ Bw	38.766666667 kHz
T2		1	848.8174167 MHz	-2.91 dBm		
M2		1	848.77715 MHz	-3.25 dBm		
D3	M2	1	41.233 kHz	-0.64 dB		

Tone 15 kHz. π/2 - BPSK MODULATION

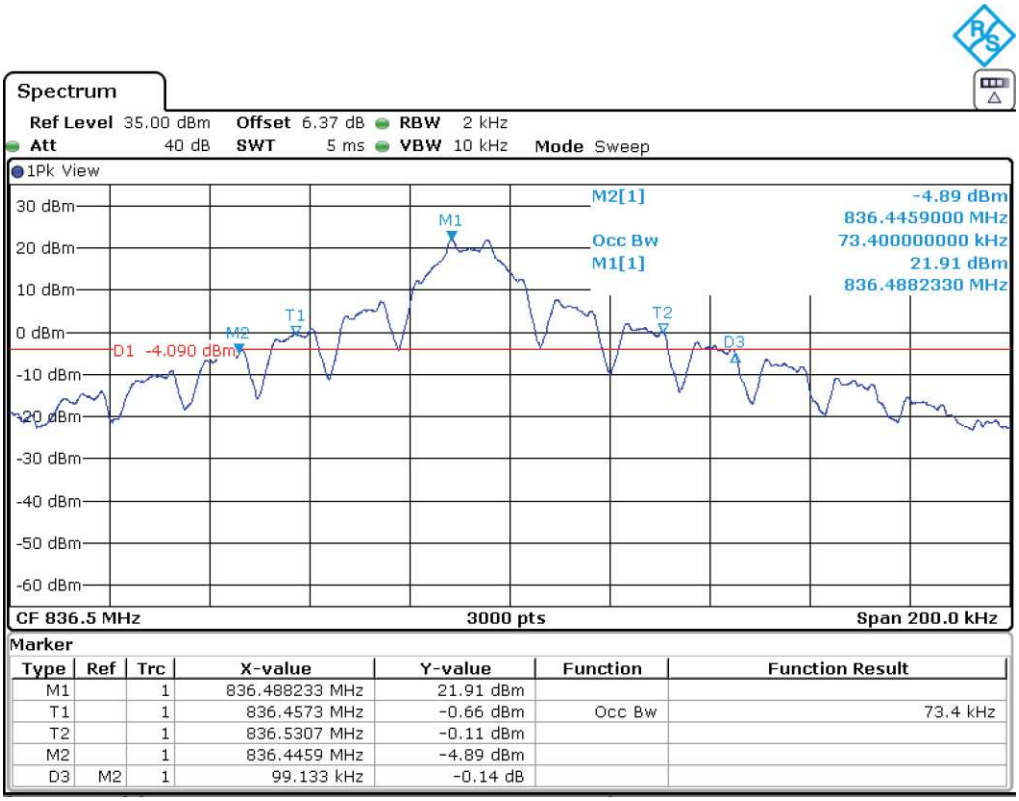
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	824.195433 MHz	22.08 dBm		
T1		1	824.1573667 MHz	-0.64 dBm	Occ Bw	73.2 kHz
T2		1	824.2305667 MHz	0.07 dBm		
M2		1	824.152167 MHz	-4.81 dBm		
D3	M2	1	92.333 kHz	0.87 dB		

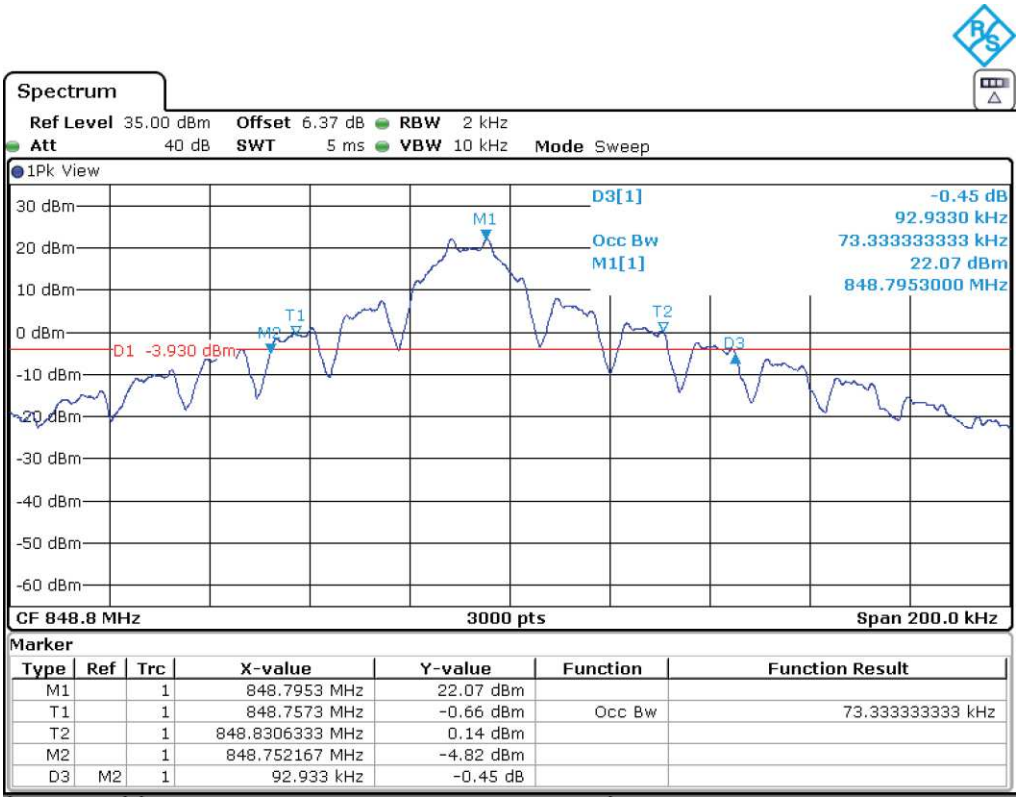
Middle Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	836.488233 MHz	21.91 dBm		
T1		1	836.4573 MHz	-0.66 dBm	Occ Bw	73.4 kHz
T2		1	836.5307 MHz	-0.11 dBm		
M2		1	836.4459 MHz	-4.89 dBm		
D3	M2	1	99.133 kHz	-0.14 dB		

Highest Channel

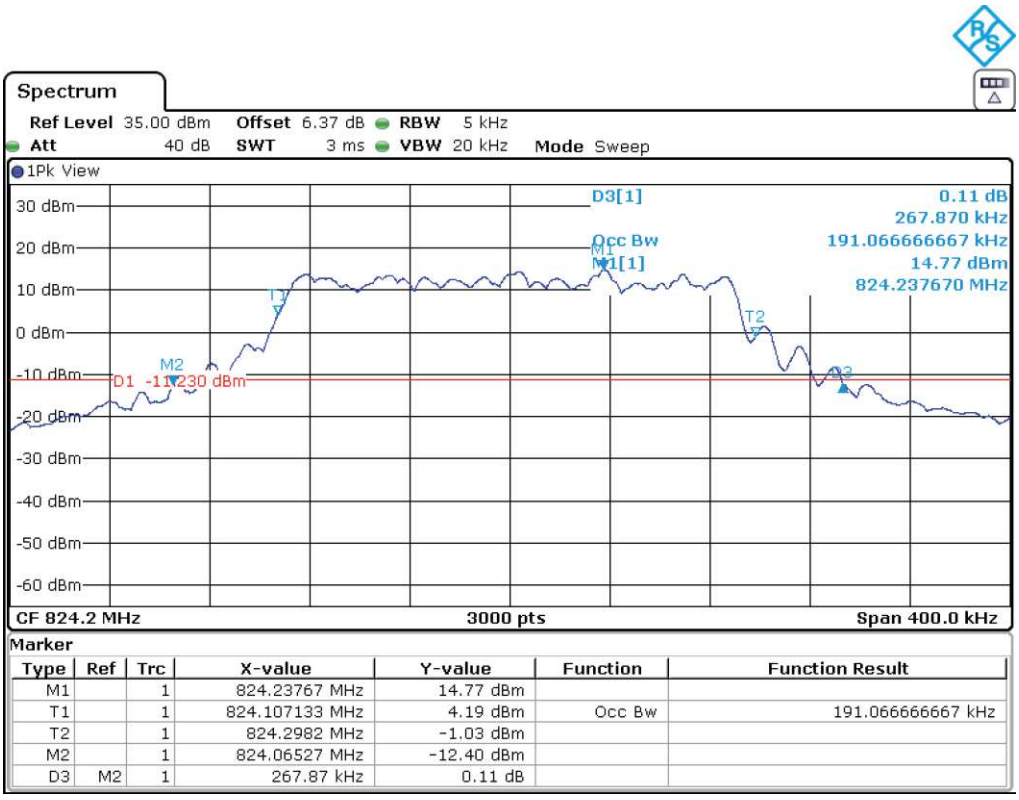


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	848.7953 MHz	22.07 dBm		
T1		1	848.7573 MHz	-0.66 dBm	Occ Bw	73.333333333 kHz
T2		1	848.8306333 MHz	0.14 dBm		
M2		1	848.752167 MHz	-4.82 dBm		
D3	M2	1	92.933 kHz	-0.45 dB		

12 Tones 15 kHz. π/4 - QPSK MODULATION

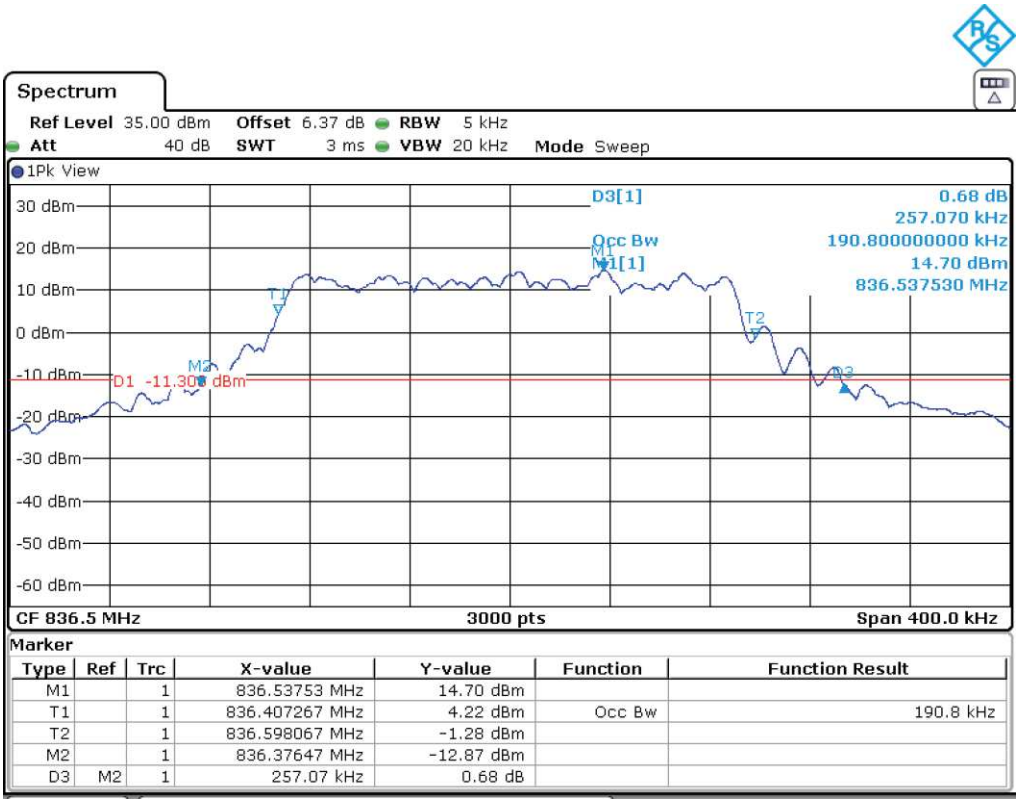
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	824.23767 MHz	14.77 dBm		
T1		1	824.107133 MHz	4.19 dBm	Occ Bw	191.066666667 kHz
T2		1	824.2982 MHz	-1.03 dBm		
M2		1	824.06527 MHz	-12.40 dBm		
D3	M2	1	267.87 kHz	0.11 dB		

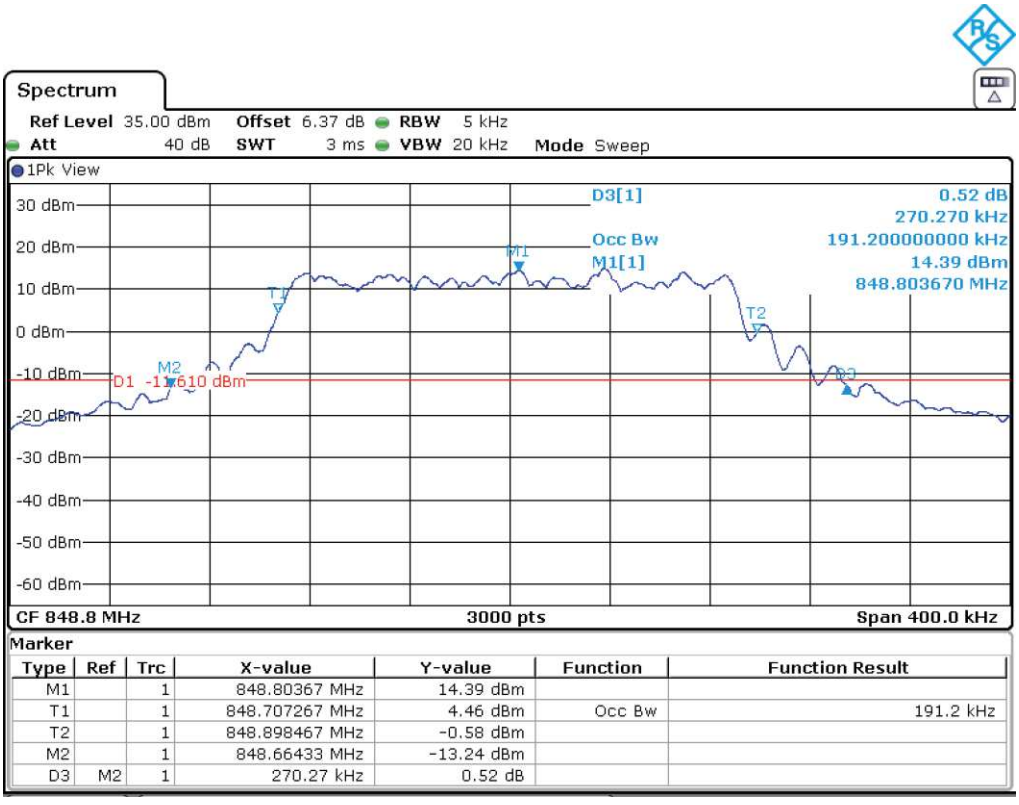
Middle Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	836.53753 MHz	14.70 dBm		
T1		1	836.407267 MHz	4.22 dBm	Occ Bw	190.8 kHz
T2		1	836.598067 MHz	-1.28 dBm		
M2		1	836.37647 MHz	-12.87 dBm		
D3	M2	1	257.07 kHz	0.68 dB		

Highest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	848.80367 MHz	14.39 dBm		
T1		1	848.707267 MHz	4.46 dBm	Occ Bw	191.2 kHz
T2		1	848.898467 MHz	-0.58 dBm		
M2		1	848.66433 MHz	-13.24 dBm		
D3	M2	1	270.27 kHz	0.52 dB		

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:

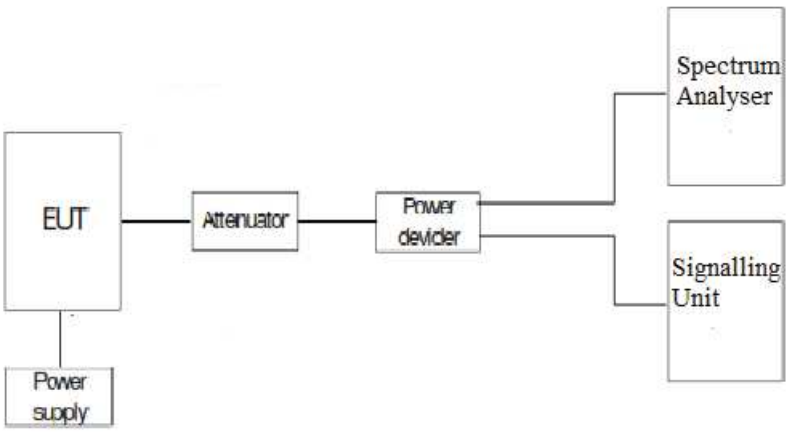
The EUT RF output connector was connected to a spectrum analyser and to the Universal Radio Communication tester R&S CMW500 (selecting maximum transmission power of the EUT and different modes of modulation) using a 50 ohm attenuator and a power divider.

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.

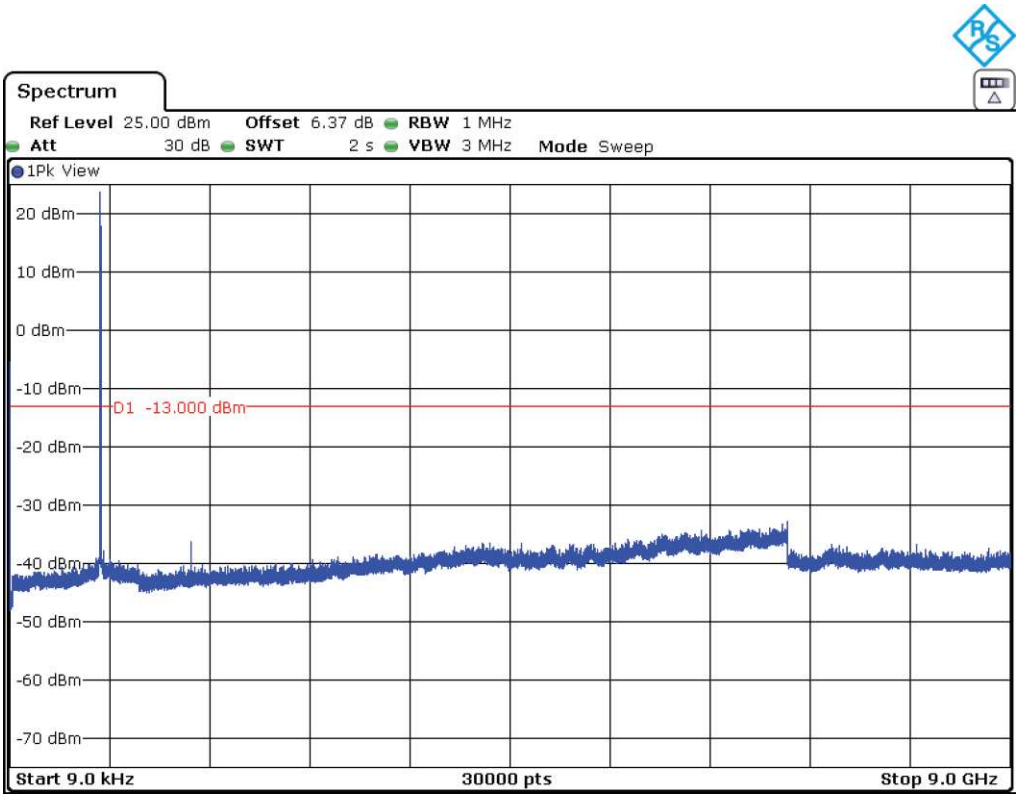
Measurement uncertainty (dB): < ± 2.76

Verdict: PASS

814-824MHz Band:

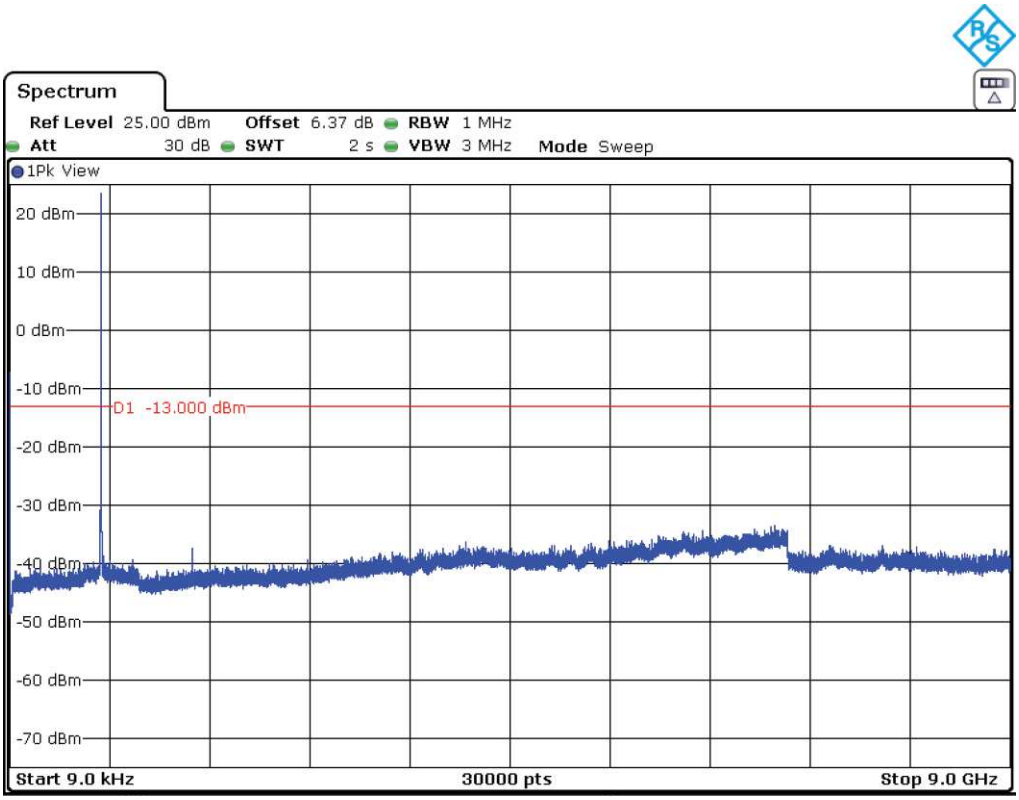
NBIoT BAND 26 (Tone 3.75 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST



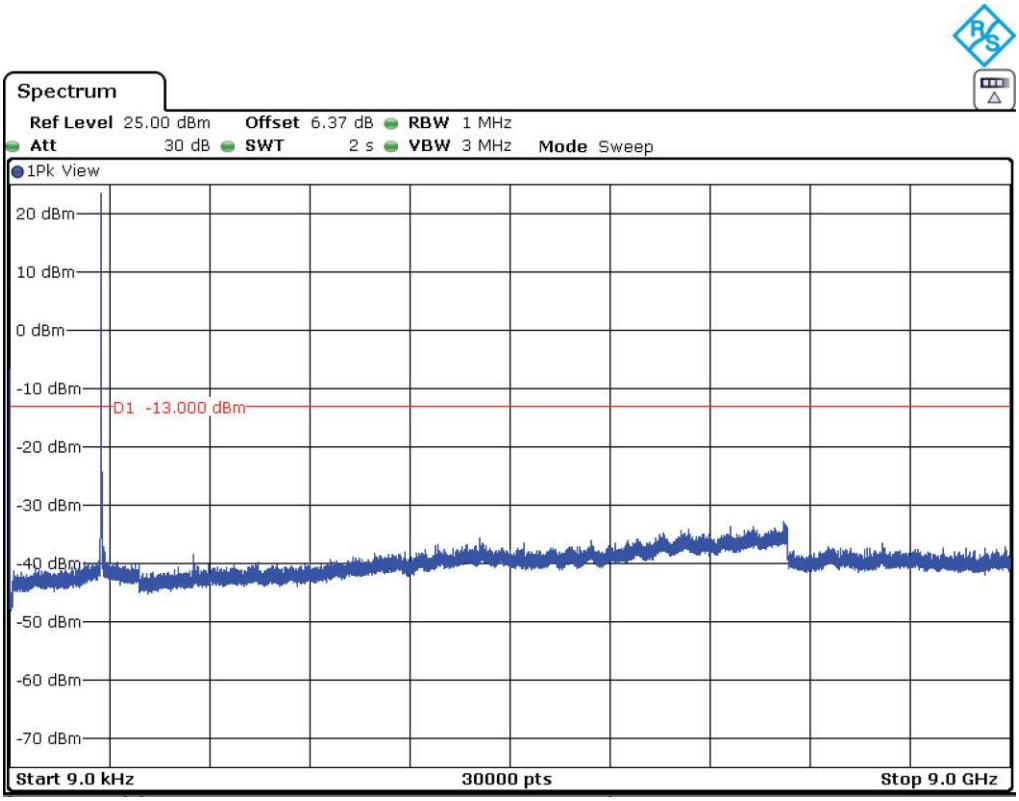
Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE



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

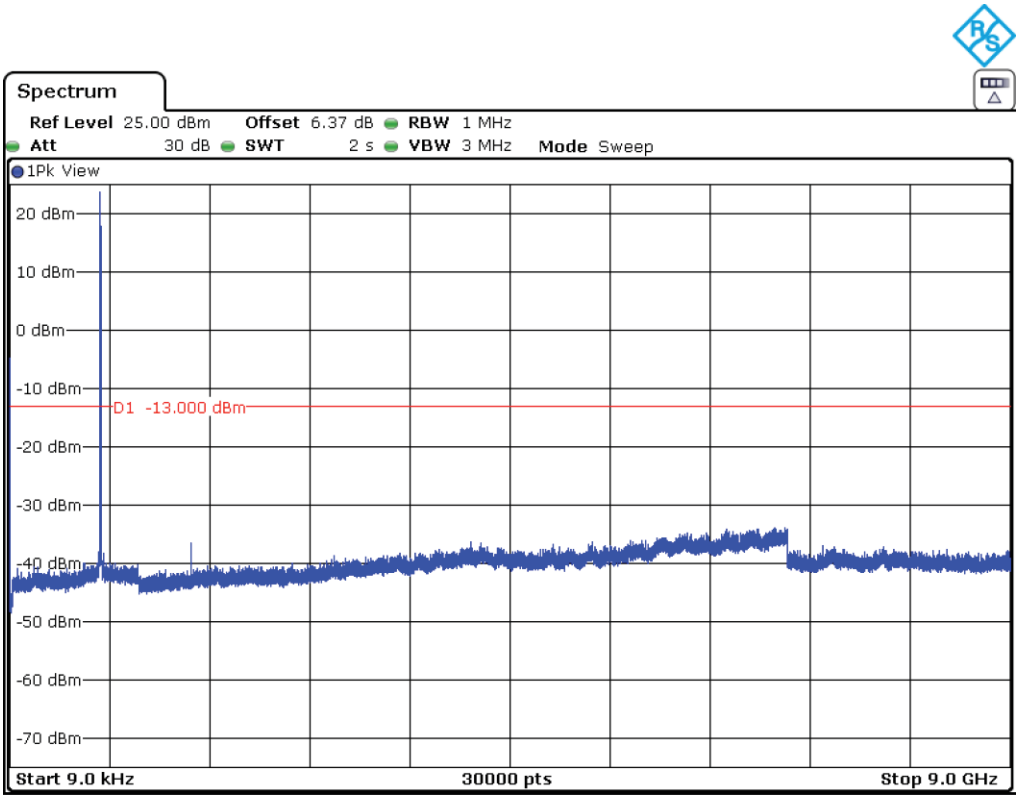
3. CHANNEL: HIGHEST



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

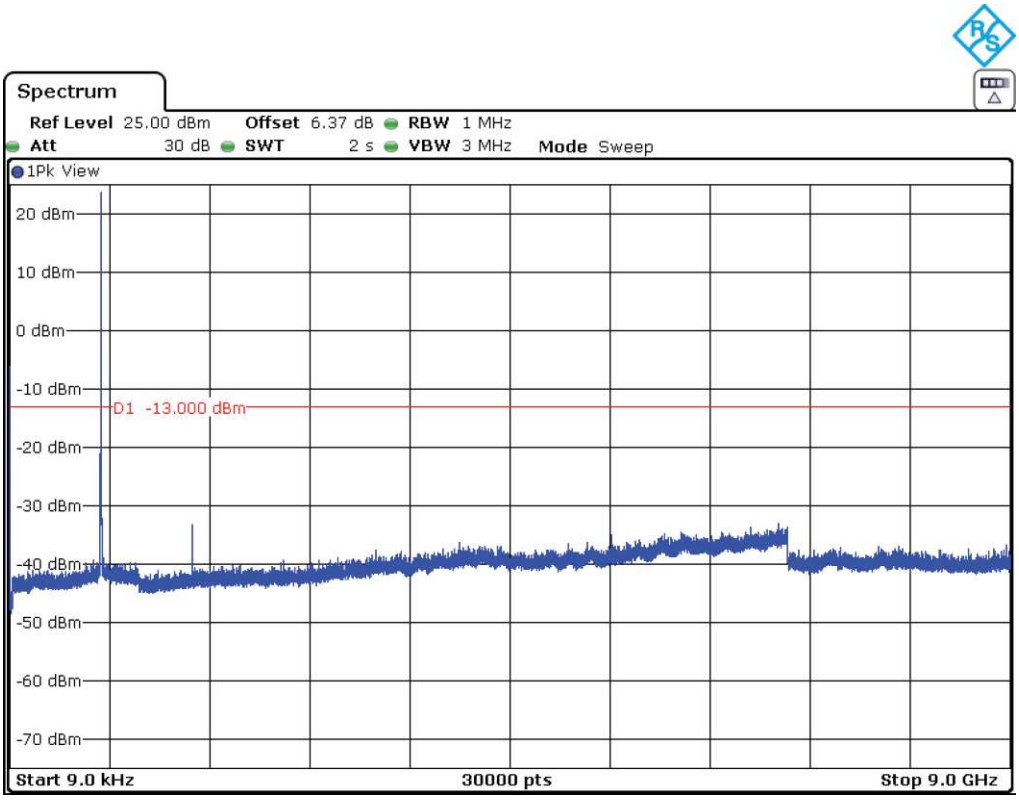
NBIoT BAND 26 (Tone 15 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST



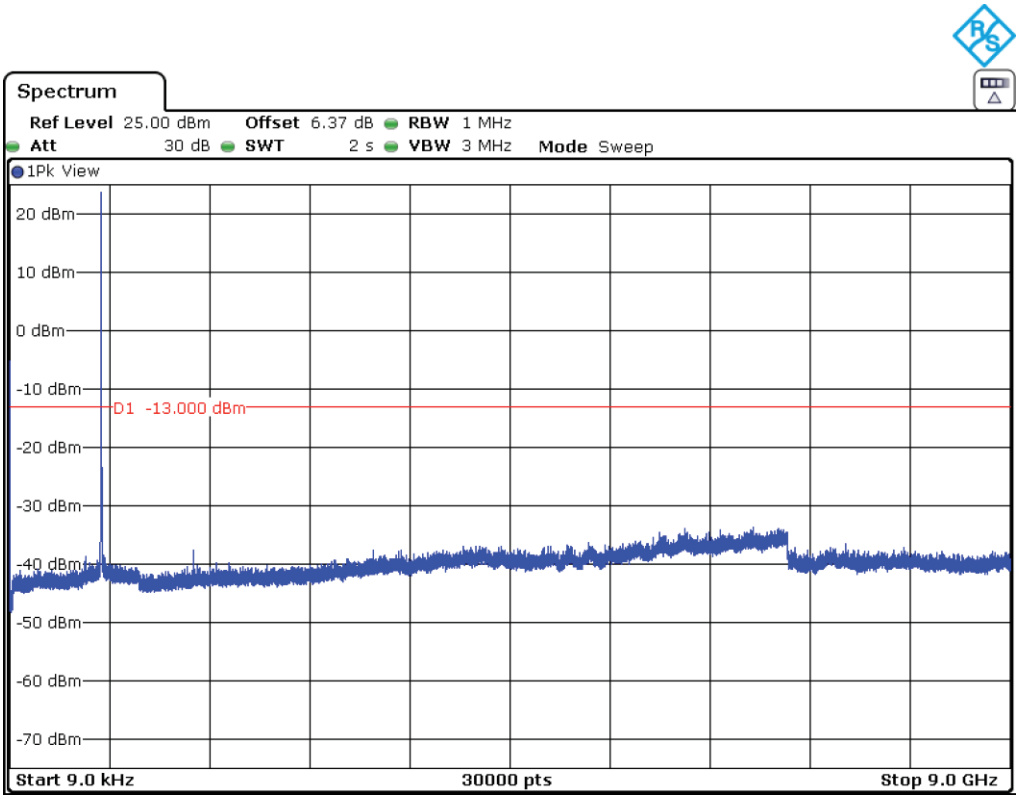
Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE



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

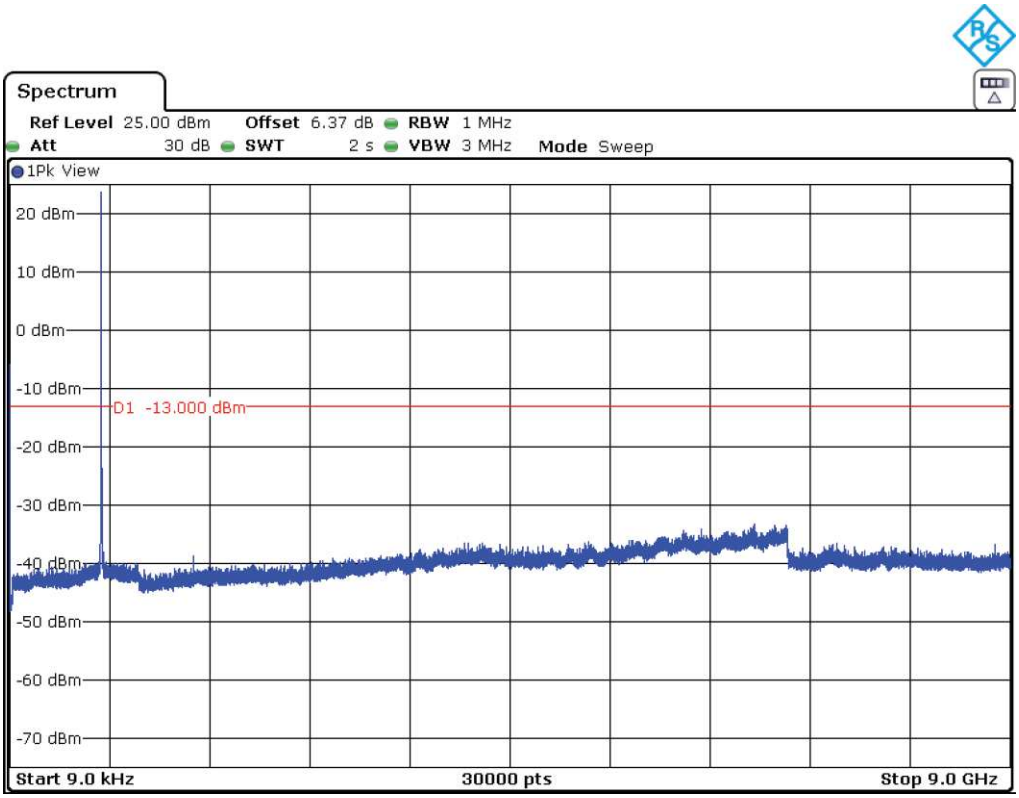
3. CHANNEL: HIGHEST



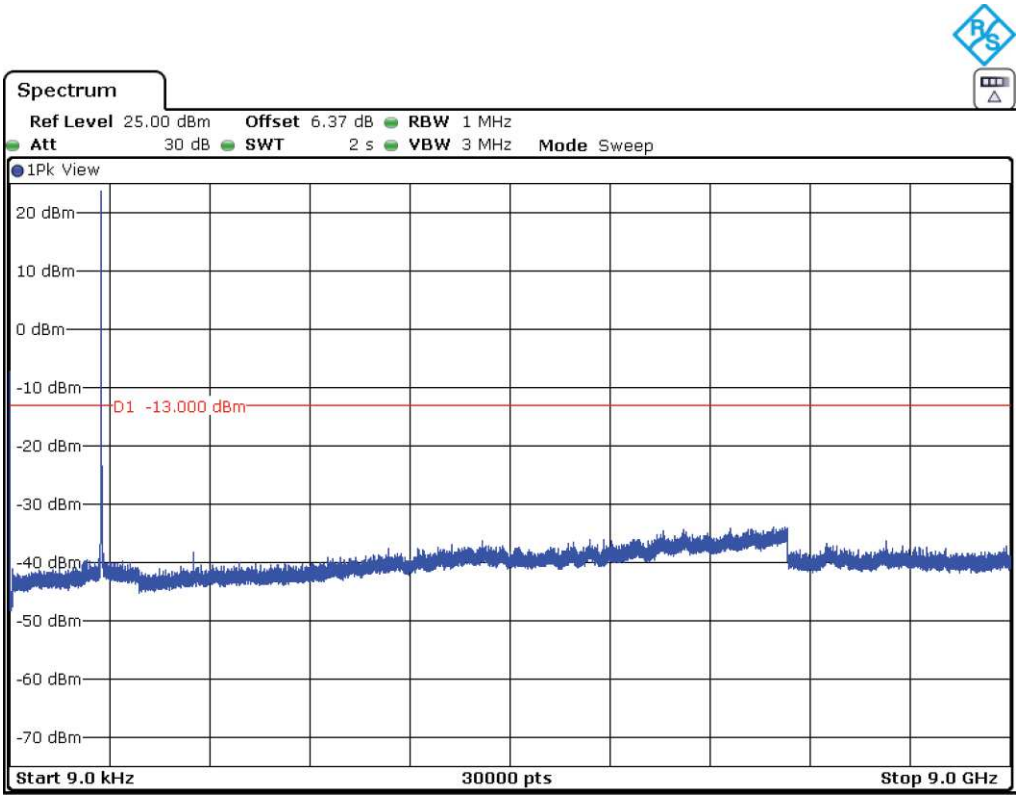
Note: The peak above the limit is the carrier frequency.

Cross-rule channel (824MHz):

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



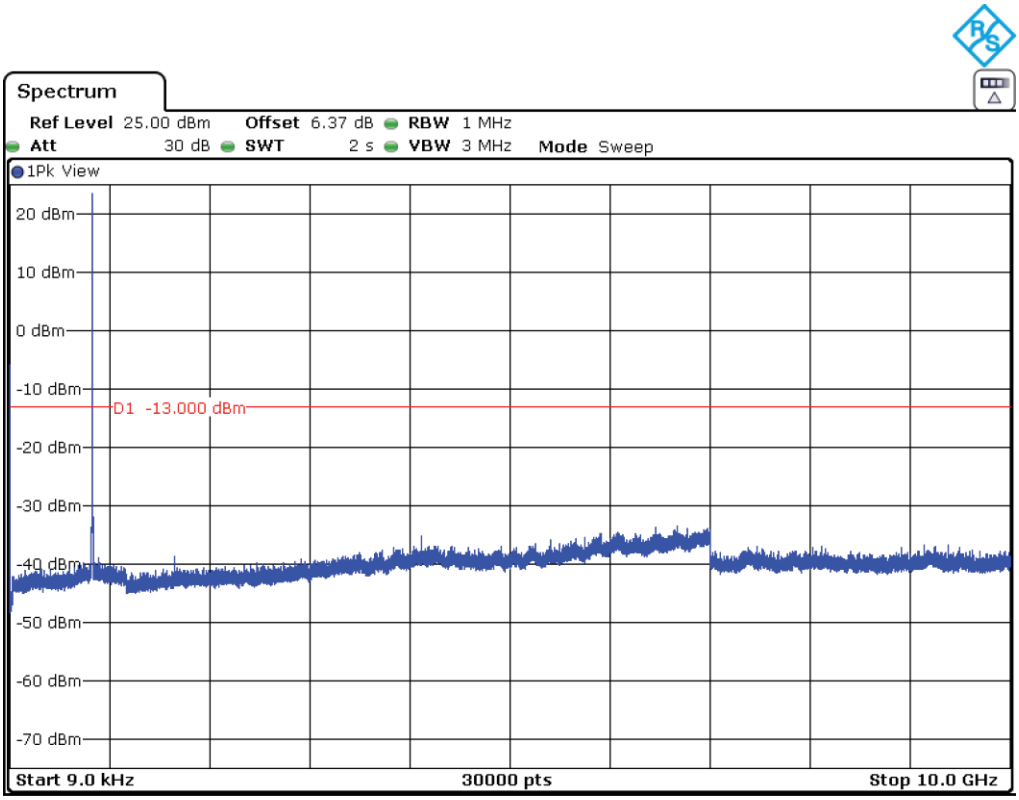
NBIoT BAND 26 (Tone 15 kHz. π/2 - BPSK MODULATION)



824-849MHz Band:

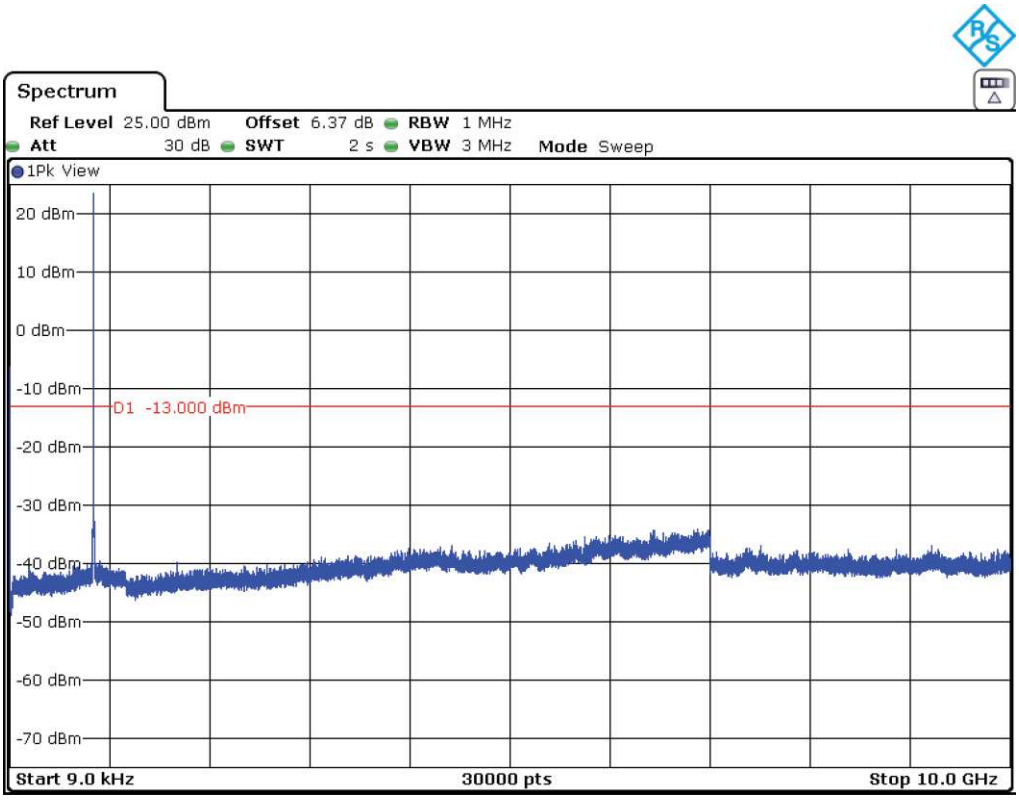
NBIoT BAND 5 (Tone 3.75 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST



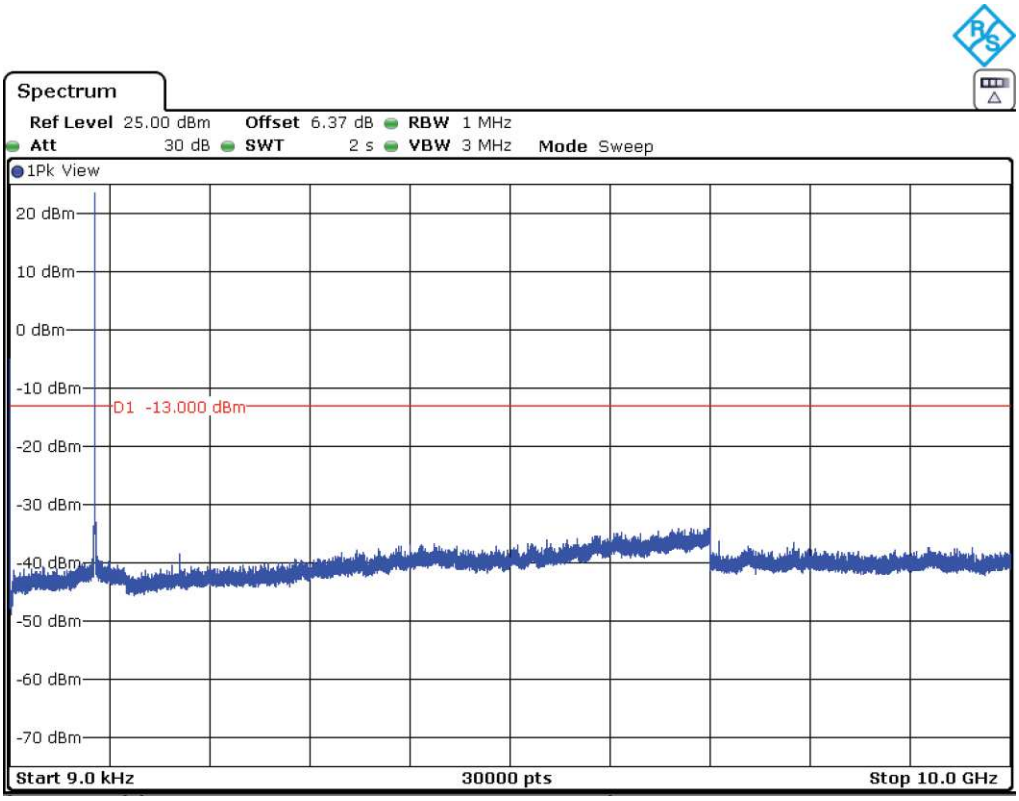
Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE



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

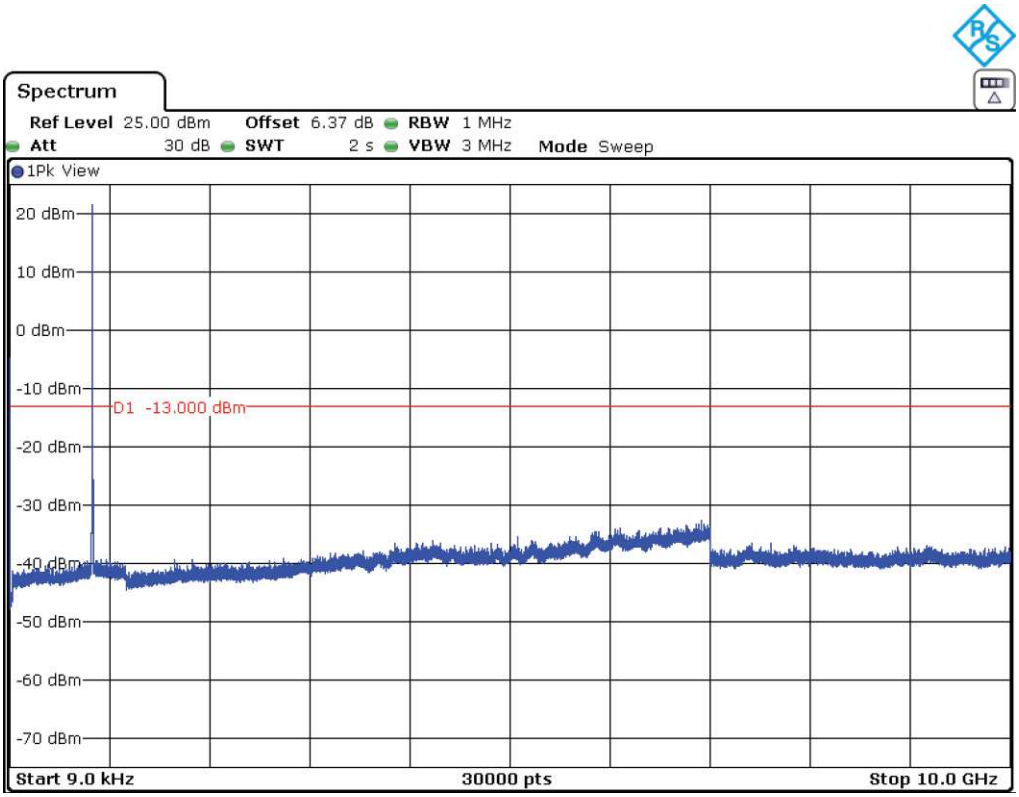
3. CHANNEL: HIGHEST



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

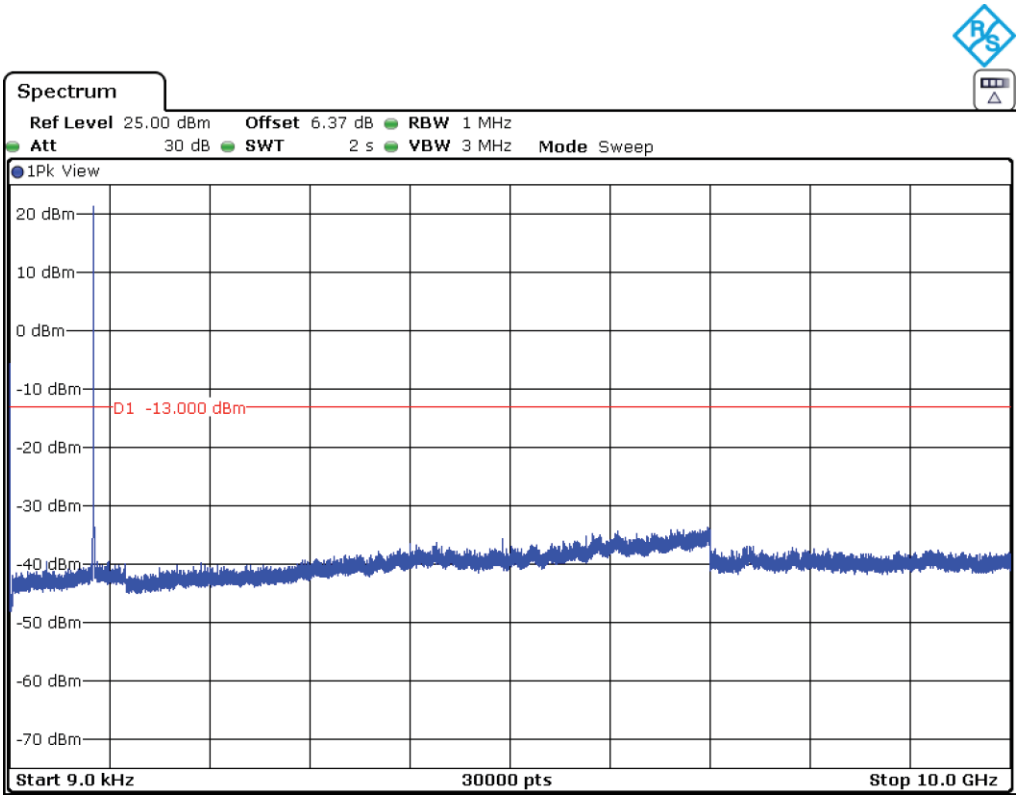
NBIoT BAND 26 (Tone 15 kHz. π/2 - BPSK MODULATION)

1. CHANNEL: LOWEST



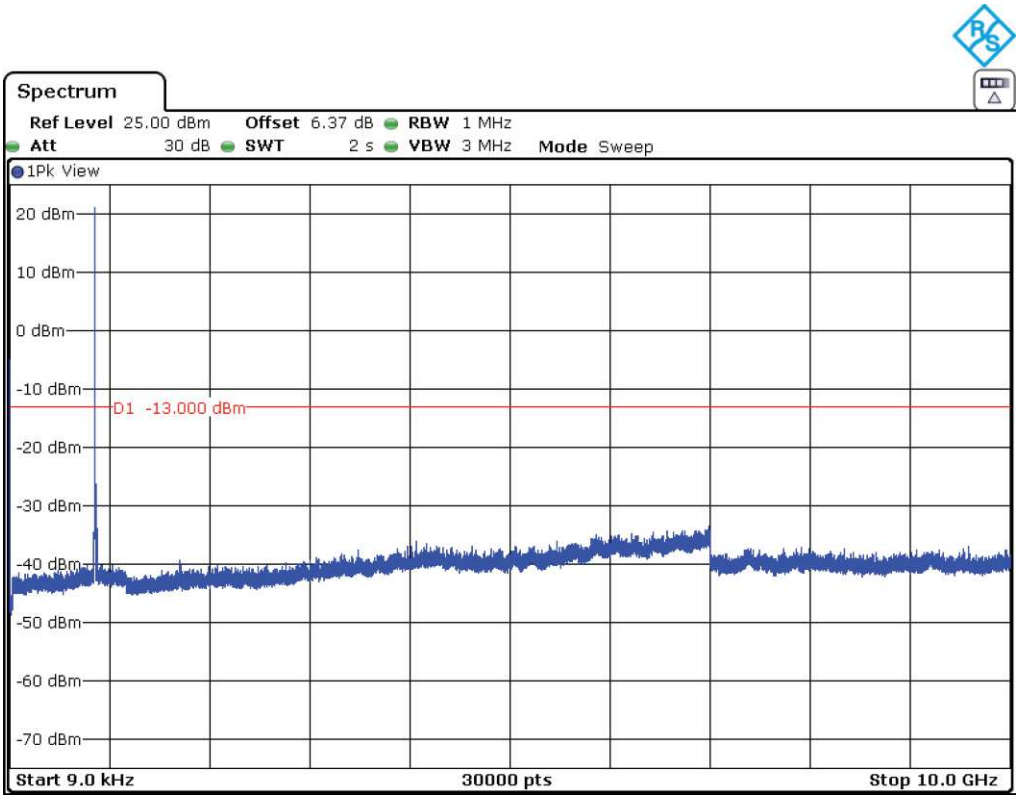
Note: The peak above the limit is the carrier frequency.

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.