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

ISED CABid: ES1909

Test report No:
NIE: 71605RRF.003A2

Test Report
Reference Standard:
USA FCC Part 27
CANADA IC RSS-130, RSS-139

(*) Identification of item tested	LTE NB-IoT Cellular communication module
(*) Trademark	Sequans Communications
(*) Model and /or type reference	GM02S
Other identification of the product	FCC ID: 2AAGMGM02SA IC: 12732A-GM02SA IMEI TAC: 01577000
(*) Features	LTE-M, NB-IoT (NB1/NB2) Release 14 3GPP HW version: V2 SW version: LR8.1.0.0-55629
Manufacturer	Sequans Communications 55 Boulevard Charles de Gaulle, 92700 Colombes, France
Test method requested, standard	USA FCC Part 27 (10-1-20 Edition). Miscellaneous Wireless Communications Services. CANADA RSS-130 Issue 2, Feb 2019. CANADA RSS-139 Issue 3, Jul. 2015. ANSI C63.26: 2015. KDB 971168 D01 Power Meas License Digital Systems v03r01, April 2018.
Summary	IN COMPLIANCE
Approved by (name / position & signature)	Rafael López EMC Consumer & RF Lab. Manager 2022.08.11 13:04:31 +02'00'
Date of issue	2022-08-03
Report template No.	FDT08_24 (*) "Data provided by the client"

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Competences and guarantees

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

DEKRA Testing and Certification 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 S.A.U. has a calibration and maintenance program for its measurement equipment.

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

General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
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Uncertainty

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

The total uncertainty of the measurement system for the radiated emissions of EUT from 30 MHz to 1 GHz is: Measurement uncertainty ≤ ±5.35 dB (with factor k = 2).

The total uncertainty of the measurement system for the radiated emissions of EUT from 1 GHz to 18 GHz is: Measurement uncertainty ≤ ±4.32 dB (with factor k = 2).

The total uncertainty of the measurement system for the radiated emissions of EUT from 18 GHz to 26 GHz is: Measurement uncertainty ≤ ±5.51 dB (with factor k = 2).

The total uncertainty of the measurement system for the conducted testing of EUT is:
RF Average Output Power: Measurement uncertainty ≤ ±0.941 dB
Frequency Stability: Measurement uncertainty ≤ ±249.55 Hz
Occupied Bandwidth: Measurement uncertainty ≤ ±0.81 kHz
26dB Bandwidth: Measurement uncertainty ≤ ±0.81 kHz
Spurious Emissions at Antenna Terminals: Measurement uncertainty ≤ ±2.76
Spurious Emissions at Antenna Terminals at Block Edges: Measurement uncertainty ≤ ±2.76 dB

Data provided by the client

The following data has been provided by the client:

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

2. The sample of the model GM02S is a multi-band module supporting cellular LTE-M Release 14. It supports HD-FDD.

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

Usage of samples

Samples undergoing test have been selected by: the client.

Id	Control Number	Description	Model	Serial No.	Date of Reception	Application
S/01	71605_13.1	LTE Cat-M Cellular communication module	GM02S	G2Q2106160105039	2022-04-04	Element Under Test
S/01	71605_16.1	External Antenna	OmniLOG 90200	--	2022-04-04	Element Under Test
S/01	71605_13.1	NEKTAR-EVK Evaluation Kit	HWPT011B5	58K2131000152	2022-04-04	Auxiliary Element
S/01	71605_14.1	UFL to SMA Cable	--	--	2022-04-04	Auxiliary Element
S/01	71605_15.1	USB Cable	--	--	2022-04-04	Auxiliary Element
S/02	71605_13.1	LTE Cat-M Cellular communication module	GM02S	G2Q2106160105039	2022-04-04	Element Under Test
S/02	71605_13.1	NEKTAR-EVK Evaluation Kit	HWPT011B5	58K2131000152	2022-04-04	Auxiliary Element
S/02	71605_14.1	UFL to SMA Cable	--	--	2022-04-04	Auxiliary Element
S/02	71605_15.1	USB Cable	--	--	2022-04-04	Auxiliary Element

Samples were used for the following test(s):

Id	Type / Comments
S/01	Radiated. / RF output: pin J1.
S/02	Conducted. / RF output: pin J1.

Test sample description

Ports.....:	Port name and description	Cable					
		Specified max length [m]	Attached during test	Shielded	Coupled to patient(3)		
	USB	2	☒	☐	☐		
			☐	☐	☐		
Supplementary information to the ports..... :	--						
Rated power supply .....:	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC: 3.3 Vdc					
Rated Power .....:	--						
Clock frequencies.....:	--						
Other parameters .....:	--						
Software version .....:	LR8.1.0.0-55629						
Hardware version .....:	V2						
Dimensions in cm (W x H x D) ....:	Not provided data						
Mounting position .....:	☒	Table top equipment					
	☐	Wall/Ceiling mounted equipment					
	☐	Floor standing equipment					
	☐	Hand-held equipment					
	☐	Other:					
Modules/parts.....:	Module/parts of test item		Type		Manufacturer		
	NEKTAR-EVK HWPT011B5		Eval Kit		Sequans		
	USB Cable						
	External antenna				Aaronia AG		
Accessories (not part of the test item) .....:	Description		Type		Manufacturer		
	--						
Documents as provided by the applicant.....:	Description		File name		Issue date		
	--						

(3) Only for Medical Equipment

Identification of the client

SEQUANS COMMUNICATIONS

55 Boulevard Charles de Gaulle, 92700 Colombes, France

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2022-04-08
Date (finish)	2022-07-28

Document history

Report number	Date	Description
71605RRF.003	2022-05-16	First release
71605RRF.003A1	2022-06-01	Second release. Modification due to typos. This modification of test report cancels and replaces the test report 71605RRF.003.
71605RRF.003A2	2022-08-03	Third release. Correction in Spurious Emissions at Antenna Terminals at Block Edges. This modification of test report cancels and replaces the test report 71605RRF.003A1.

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 %

In the semi-anechoic chamber, the following limits were not exceeded during the test.

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %

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 %

Remarks and comments

The tests have been performed by the technical personnel: Alfonso Gutiérrez and Miguel Manuel López.

Used instrumentation:

Equipment	Model	Manufacturer	Next Calibration
SEMIANECHOIC ABSORBER LINED CHAMBER IV	FACT 3 200 STP	ETS LINDGREN	2024-06-07
SHIELDED ROOM	S101	ETS LINDGREN	N.A.
EMI TEST RECEIVER 9kHz-7GHz	ESR7	ROHDE AND SCHWARZ	2023-11-08
SIGNAL AND SPECTRUM ANALYZER 10Hz-40GHz	FSV40	ROHDE AND SCHWARZ	2023-10-22
HYBRID BILOG ANTENNA 30MHz-6GHz	3142E	ETS LINDGREN	2023-10-29
HORN ANTENNA 1-18GHz	BBHA 9120 D	SCHWARZBECK	2023-08-24
HORN ANTENNA 18-40GHz	BBHA 9170	SCHWARZBECK	2023-05-05
PRE-AMPLIFIER G>30dB 1GHz-18GHz	BLMA 0118-3A	BONN ELEKTRONIK	2022-12-01
PRE-AMPLIFIER G>30dB 17-40GHz	BLMA 1840-4A	BLMA 1840-4A	2022-09-08
SIGNAL AND SPECTRUM ANALYZER 10Hz-40GHz	FSV40	ROHDE AND SCHWARZ	2023-02-26
SIGNAL ANALYZER 20Hz-8GHz	FSQ8	ROHDE AND SCHWARZ	2022-10-06
TEMPERATURE CHAMBER	MK 56	BINDER	2023-03-22
DC POWER SUPPLY 40 V / 40 A	NGPE 40/40	ROHDE AND SCHWARZ	N.A.
DIGITAL MULTIMETER	179	FLUKE	2022-10-19

Testing verdicts

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

Summary

FCC PART 27 / RSS-130, RSS-139		
Requirement – Test case	**Verdict**	**Remark**
FCC 27.50 / RSS-130 4.6, RSS-139 6.5: RF Output Power	P	
FCC 2.1047 / RSS-130 4.2, RSS-139 6.2: Modulation Characteristics	P	
FCC 27.54 / RSS-130 4.5, RSS-139 6.4: Frequency Stability	P	
FCC 2.1049: Occupied Bandwidth	P	
FCC 27.53 / RSS-130 4.7, RSS-139 6.6: Spurious Emissions at Antenna Terminals	P	
FCC 27.53 / RSS-130 4.7, RSS-139 6.6: Radiated Emissions	P	
Supplementary information and remarks: None.		

Appendix A: Test results for FCC Part 27 / RSS-130, RSS-139

INDEX

TEST CONDITIONS

(*): Data provided by the client.

Power supply (V):

Vn = 3.3 Vdc (*)

Vmin = 2.805 Vdc

Vmax = 3.795 Vdc

The subscripts n, min and max indicate voltage test conditions: nominal, minimum and maximum respectively.

Type of power supply: USB powered or DC Voltage from external power supply.

ANTENNA (*):

Device with external and internal antennas.

After a preliminary scan, the determined worst case for the Radiated tests is the external antenna.

For the Conducted tests, the gain of the internal antenna is used.

Declared Gain for antennas:

Low bands	Gain (dBi)	Antenna type
LTE Bands 12, 13 & 17	+1.1	Internal
	+0.17	External

Middle bands	Gain (dBi)	Antenna type
LTE Bands 4 & 66	+2.4	Internal
	+2.1	External

TEST FREQUENCIES:

NBIoT. π/2 - BPSK and π/4 - QPSK modulations (BAND 4)

Channel (Frequency, MHz)		
Low	Middle	High
19952 (1710.2)	20175 (1732.5)	20398 (1754.8)

NOTE: Band 4 is completely included in band 66, so the channels of band 66 were tested to give conformity to the assigned block 1710-1780 MHz. Only high block edge of band 4 was tested to give conformity to the assigned block 1710-1755 MHz.

NBIoT. π/2 - BPSK and π/4 - QPSK modulations (BAND 12)

Channel (Frequency, MHz)		
Low	**Middle**	**High**
23012 (699.2)	23095 (707.5)	23178 (715.8)

NBIoT. π/2 - BPSK and π/4 - QPSK modulations (BAND 13)

Channel (Frequency, MHz)		
Low	**Middle**	**High**
23182 (777.2)	23230 (782)	23278 (786.8)

NBIoT. π/2 - BPSK and π/4 - QPSK modulations (BAND 17)

Channel (Frequency, MHz)		
Low	**Middle**	**High**
23732 (704.2)	23790 (710)	23848 (715.8)

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

NBIoT. π/2 - BPSK and π/4 - QPSK modulations (BAND 66)

Channel (Frequency, MHz)		
Low	**Middle**	**High**
131974 (1710.2)	132322 (1745)	132670 (1779.8)

RF Output Power

Limits

FCC §27.50 (b) (10):

Portable stations (hand-held devices) transmitting in the 746-757 MHz, 776-788 MHz, and 805-806 MHz bands are limited to 3 watts ERP.

FCC §27.50 (c) (10):

Portable stations (hand-held devices) in the 600 MHz uplink band and the 698-746 MHz band, and fixed and mobile stations in the 600 MHz uplink band are limited to 3 watts ERP.

FCC §27.50 (d) (4) & (5):

Fixed, mobile, and portable (hand-held) stations operating in the 1710-1755 MHz band and mobile and portable stations operating in the 1695-1710 MHz and 1755-1780 MHz bands are limited to 1 watt EIRP. Fixed stations operating in the 1710-1755 MHz band are limited to a maximum antenna height of 10 meters above ground. Mobile and portable stations operating in these bands must employ a means for limiting power to the minimum necessary for successful communications.

In measuring transmissions in this band using an average power technique, the peak-to-average ratio (PAR) of the transmission may not exceed 13 dB.

RSS-130 Clause 4.6:

4.6.1 General

The transmitter output power shall be measured in terms of average power. In addition, the peak-to-average power ratio (PAPR) of the transmitter shall not exceed 13 dB for more than 0.1% of the time and shall use a signal corresponding to the High PAPR during periods of continuous transmission.

4.6.3 Frequency bands 698-756 MHz and 777-787 MHz

The e.r.p. shall not exceed 30 watts for mobile equipment and outdoor fixed subscriber equipment. The e.r.p. shall not exceed 3 watts for portable equipment and indoor fixed subscriber equipment.

RSS-139 Clause 6.5:

The equivalent isotropically radiated power (e.i.r.p.) for mobile and portable transmitters shall not exceed one watt. The e.i.r.p. for fixed and base stations in the band 1710-1780 MHz shall not exceed one watt.

In addition, the peak to average power ratio (PAPR) of the equipment shall not exceed 13 dB for more than 0.1% of the time, using a signal that corresponds to the High 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 maximum declared 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:

$$E.R.P. = E.I.R.P. – 2.15\ dB$$

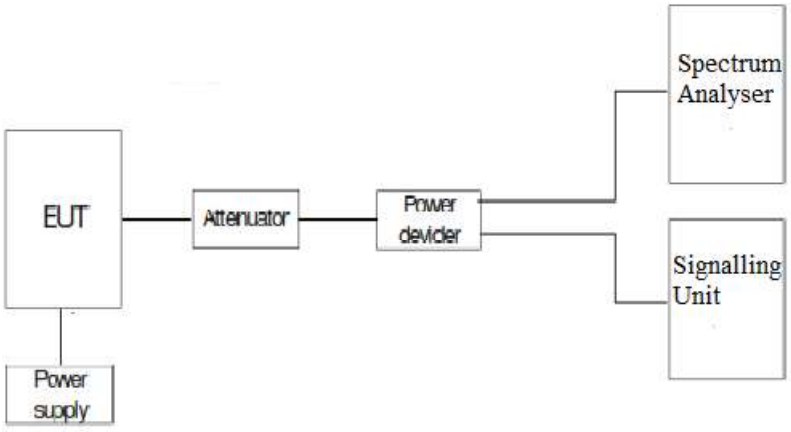
The peak-to-average power ratio (PAPR) is measured using an attenuator, power splitter and spectrum analyser with a Complementary Cumulative Distribution Function implemented.

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

NBIoT Band 12:

Channel	Freq. (MHz)	Modulation	BW (kHz)	No. of tones	Offset Tone	Average Power (dBm)	PAPR (dB)
23012	699.2	π/2 - BPSK	3.75	1	0	21.91	(*)
				1	47	21.91	(*)
			15	1	0	22.16	(*)
				1	11	22.19	(*)
		π/4 - QPSK	3.75	1	0	21.95	(*)
				1	47	21.94	(*)
			15	1	0	22.17	(*)
				1	11	22.18	(*)
				3	0	22.38	5.69
				3	6	22.63	5.63
				6	0	22.46	4.85
				6	6	22.48	4.82
				12	0	22.52	7.15
23095	707.5	π/2 - BPSK	3.75	1	0	21.90	(*)
				1	47	21.93	(*)
			15	1	0	22.08	(*)
				1	11	22.13	(*)
		π/4 - QPSK	3.75	1	0	21.92	(*)
				1	47	21.92	(*)
			15	1	0	22.10	(*)
				1	11	22.10	(*)
				3	0	22.36	5.64
				3	6	22.57	5.60
				6	0	22.39	4.82
				6	6	22.39	4.82
				12	0	22.42	6.91
23178	715.8	π/2 - BPSK	3.75	1	0	21.90	(*)
				1	47	21.92	(*)
			15	1	0	22.14	(*)
				1	11	22.12	(*)
		π/4 - QPSK	3.75	1	0	22.02	(*)
				1	47	21.91	(*)
			15	1	0	22.11	(*)
				1	11	22.10	(*)
				3	0	22.35	5.62
				3	6	22.58	5.53
				6	0	22.48	4.77
				6	6	22.48	4.72
				12	0	22.56	7.05

(*) Preliminary measurements determined QPSK modulation, 3, 6 or 12 tones with 15kHz BW as the worst cases.

Channel	Measured maximum average power at antenna port (dBm)	Maximum declared antenna gain (dBi)	Maximum equivalent isotropically radiated power E.I.R.P. (dBm)	Maximum effective radiated power E.R.P. (dBm)	Maximum PAPR (dB)
Low	22.63	1.10	23.73	21.58	7.15
Middle	22.57	1.10	23.67	21.52	6.91
High	22.58	1.10	23.68	21.53	7.05

Verdict

Pass

NBIoT Band 13:

Channel	Freq. (MHz)	Modulation	BW (kHz)	No. of tones	Offset Tone	Average Power (dBm)	PAPR (dB)
23182	777.2	π/2 - BPSK	3.75	1	0	22.24	(*)
				1	47	22.24	(*)
			15	1	0	22.45	(*)
				1	11	22.43	(*)
		π/4 - QPSK	3.75	1	0	22.24	(*)
				1	47	22.25	(*)
			15	1	0	22.43	(*)
				1	11	22.44	(*)
				3	0	22.69	5.55
				3	6	22.91	5.46
				6	0	22.83	4.55
				6	6	22.80	4.62
				12	0	22.81	4.10
23230	782	π/2 - BPSK	3.75	1	0	22.37	(*)
				1	47	22.37	(*)
			15	1	0	22.53	(*)
				1	11	22.50	(*)
		π/4 - QPSK	3.75	1	0	22.40	(*)
				1	47	22.41	(*)
			15	1	0	22.51	(*)
				1	11	22.52	(*)
				3	0	22.79	5.54
				3	6	23.01	5.46
				6	0	22.81	4.31
				6	6	22.80	4.56
				12	0	22.86	4.55
23278	786.8	π/2 - BPSK	3.75	1	0	22.27	(*)
				1	47	22.29	(*)
			15	1	0	22.43	(*)
				1	11	22.46	(*)
		π/4 - QPSK	3.75	1	0	22.30	(*)
				1	47	22.32	(*)
			15	1	0	22.42	(*)
				1	11	22.43	(*)
				3	0	22.67	5.58
				3	6	22.93	5.50
				6	0	22.77	4.47
				6	6	22.81	4.54
				12	0	22.86	4.09

(*) Preliminary measurements determined QPSK modulation, 3, 6 or 12 tones with 15kHz BW as the worst cases.

Channel	Measured maximum average power at antenna port (dBm)	Maximum declared antenna gain (dBi)	Maximum equivalent isotropically radiated power E.I.R.P. (dBm)	Maximum effective radiated power E.R.P. (dBm)	Maximum PAPR (dB)
Low	22.91	1.10	24.01	21.86	5.55
Middle	23.01	1.10	24.11	21.96	5.54
High	22.93	1.10	24.03	21.88	5.58

Verdict

Pass

NBIoT Band 66:

Channel	Freq. (MHz)	Modulation	BW (kHz)	No. of tones	Offset Tone	Average Power (dBm)	PAPR (dB)
131974	1710.2	π/2 - BPSK	3.75	1	0	21.63	(*)
				1	47	21.67	(*)
			15	1	0	21.99	(*)
				1	11	21.99	(*)
		π/4 - QPSK	3.75	1	0	21.71	(*)
				1	47	21.71	(*)
			15	1	0	22.06	(*)
				1	11	22.09	(*)
				3	0	22.41	5.75
				3	6	22.65	5.69
				6	0	22.47	4.77
				6	6	22.52	4.70
				12	0	22.55	4.13
132322	1745	π/2 - BPSK	3.75	1	0	21.70	(*)
				1	47	21.70	(*)
			15	1	0	22.03	(*)
				1	11	22.03	(*)
		π/4 - QPSK	3.75	1	0	21.77	(*)
				1	47	21.73	(*)
			15	1	0	22.13	(*)
				1	11	22.08	(*)
				3	0	22.47	5.80
				3	6	22.67	5.71
				6	0	22.59	4.79
				6	6	22.63	4.81
				12	0	22.64	4.72
132670	1779.8	π/2 - BPSK	3.75	1	0	21.79	(*)
				1	47	21.84	(*)
			15	1	0	22.18	(*)
				1	11	22.14	(*)
		π/4 - QPSK	3.75	1	0	21.84	(*)
				1	47	21.87	(*)
			15	1	0	22.23	(*)
				1	11	22.24	(*)
				3	0	22.54	4.66
				3	6	22.76	3.45
				6	0	22.72	4.63
				6	6	22.73	3.73
				12	0	22.71	3.98

(*) Preliminary measurements determined QPSK modulation, 3, 6 or 12 tones with 15kHz BW as the worst cases.

Channel	Measured maximum average power at antenna port (dBm)	Maximum declared antenna gain (dBi)	Maximum equivalent isotropically radiated power E.I.R.P. (dBm)	Maximum effective radiated power E.R.P. (dBm)	Maximum PAPR (dB)
Low	22.65	2.40	25.05	22.90	5.75
Middle	22.67	2.40	25.07	22.92	5.80
High	22.73	2.40	25.13	22.98	4.66

Verdict

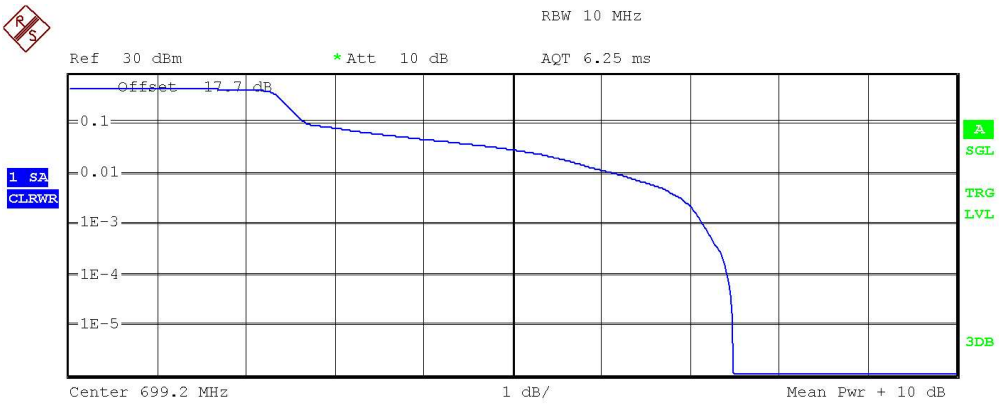
Pass

Attachments
Peak-to-Average Power Ratio (PAPR)

NBIoT Band 12.

Preliminary measurements determined QPSK modulation, 12 tones with 15kHz BW, Offset Tone = 0 as the worst case. Next plots show the results for this worst-case configuration.

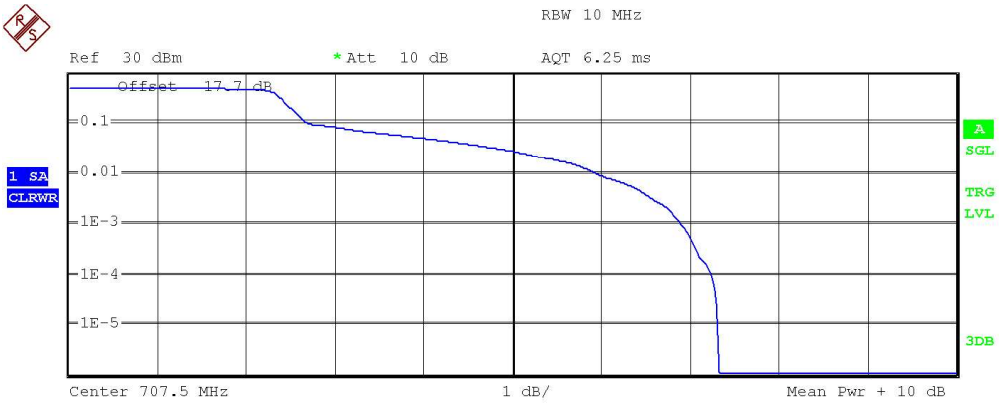
- Low Channel:



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

	Trace 1
Mean	19.67 dBm
Peak	27.15 dBm
Crest	7.48 dB
10 %	2.69 dB
1 %	6.19 dB
.1 %	7.15 dB
.01 %	7.42 dB

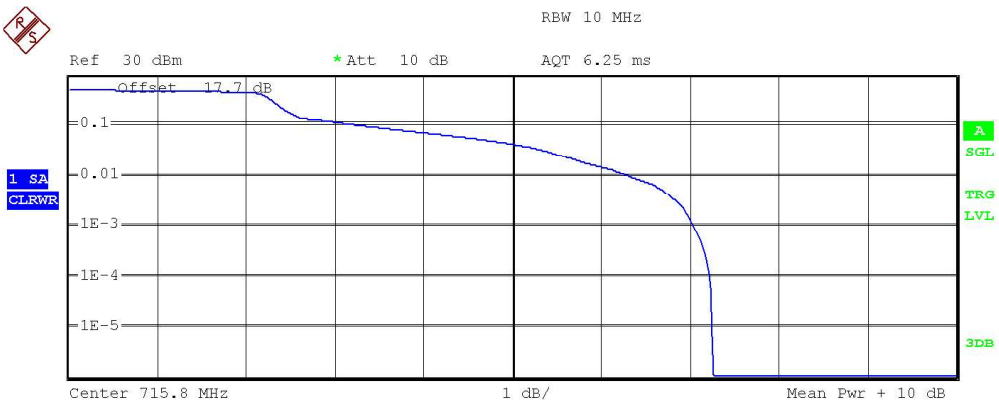
- Middle Channel:



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

	Trace 1
Mean	19.62 dBm
Peak	26.94 dBm
Crest	7.32 dB
10 %	2.71 dB
1 %	5.95 dB
.1 %	6.91 dB
.01 %	7.24 dB

- High Channel:



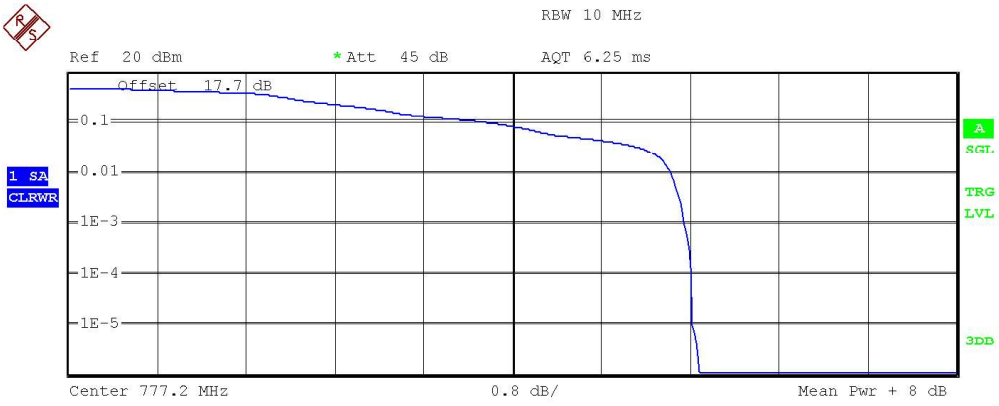
Complementary Cumulative Distribution Function
NOF samples: 100000, Usable BW: 11.2MHz

	Trace 1
Mean	19.82 dBm
Peak	27.07 dBm
Crest	7.25 dB
10 %	3.27 dB
1 %	6.30 dB
.1 %	7.05 dB
.01 %	7.23 dB

NBIoT Band 13.

Preliminary measurements determined QPSK modulation, 3 tones with 15kHz BW, Offset Tone = 0 as the worst case. Next plots show the results for this worst-case configuration.

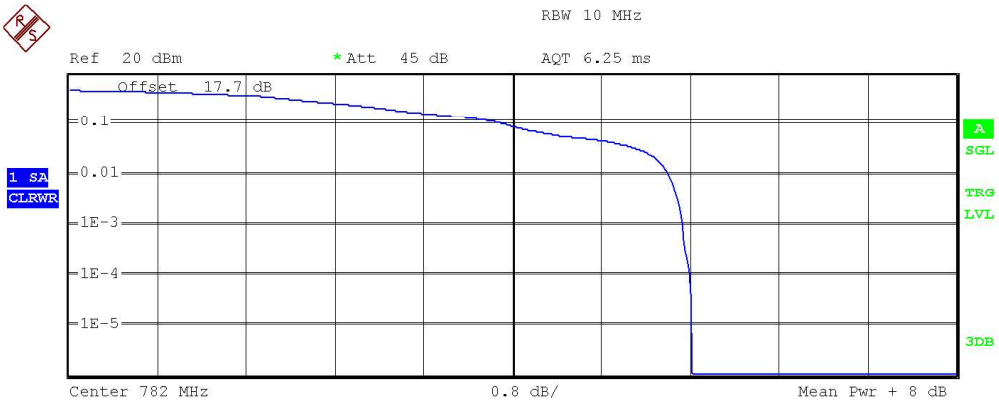
- Low Channel:



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

	Trace 1
Mean	20.70 dBm
Peak	26.39 dBm
Crest	5.69 dB
10 %	3.82 dB
1 %	5.44 dB
.1 %	5.55 dB
.01 %	5.62 dB

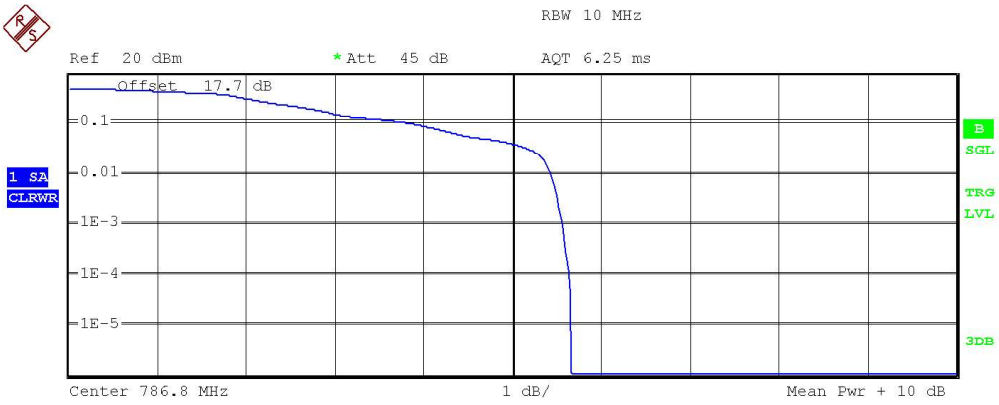
- Middle Channel:



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

	Trace 1
Mean	20.77 dBm
Peak	26.39 dBm
Crest	5.62 dB
10 %	3.91 dB
1 %	5.41 dB
.1 %	5.54 dB
.01 %	5.60 dB

- High Channel:



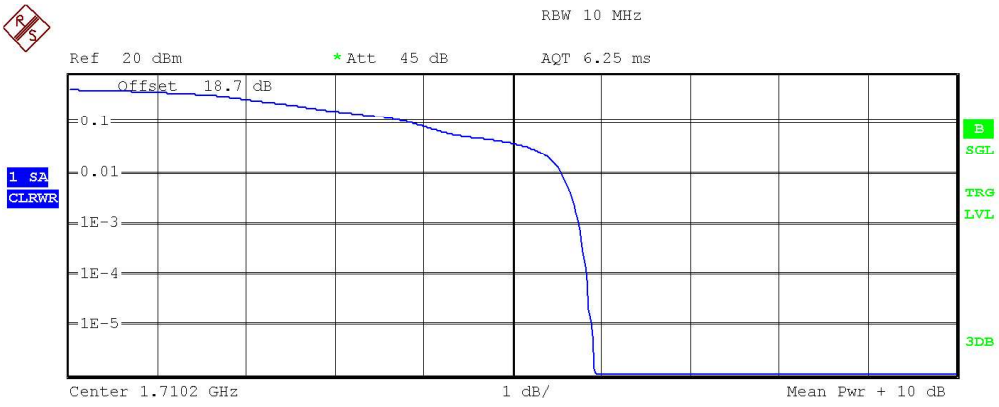
Complementary Cumulative Distribution Function
NOF samples: 100000, Usable BW: 11.2MHz

	Trace 1
Mean	20.61 dBm
Peak	26.27 dBm
Crest	5.66 dB
10 %	3.85 dB
1 %	5.43 dB
.1 %	5.58 dB
.01 %	5.64 dB

NBIoT Band 66.

Preliminary measurements determined QPSK modulation, 3 tones with 15kHz BW, Offset Tone = 0 as the worst case. Next plots show the results for this worst-case configuration.

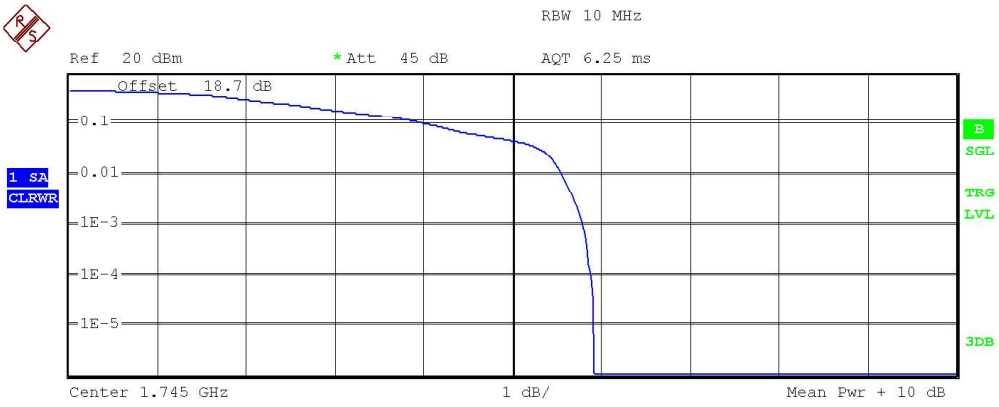
- Low Channel:



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

	Trace 1
Mean	20.39 dBm
Peak	26.32 dBm
Crest	5.92 dB
10 %	3.89 dB
1 %	5.56 dB
.1 %	5.75 dB
.01 %	5.85 dB

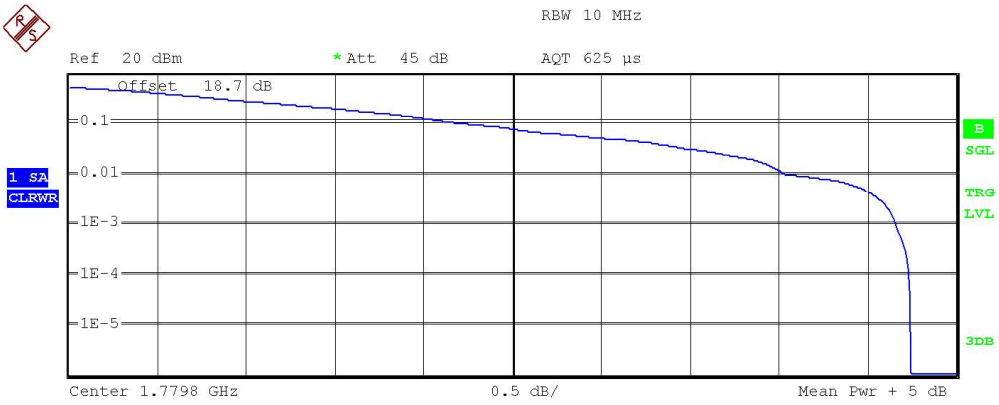
- Middle Channel:



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

	Trace 1
Mean	20.52 dBm
Peak	26.44 dBm
Crest	5.92 dB
10 %	4.02 dB
1 %	5.56 dB
.1 %	5.80 dB
.01 %	5.88 dB

- High Channel:



Complementary Cumulative Distribution Function
NOF samples: 10000, Usable BW: 11.2MHz

	Trace 1
Mean	22.77 dBm
Peak	27.51 dBm
Crest	4.74 dB
10 %	2.20 dB
1 %	4.03 dB
.1 %	4.66 dB
.01 %	4.74 dB

Frequency Stability

Limits

FCC §27.54 & §2.1055. The frequency stability shall be sufficient to ensure that the fundamental emissions stay within the authorized bands of operation.

RSS-130, Clause 4.5 & RSS-139, Clause 6.4. The frequency stability shall be sufficient to ensure that the occupied bandwidth remains within each frequency block range when tested at the temperature and supply voltage variations specified in RSS-Gen.

Method

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

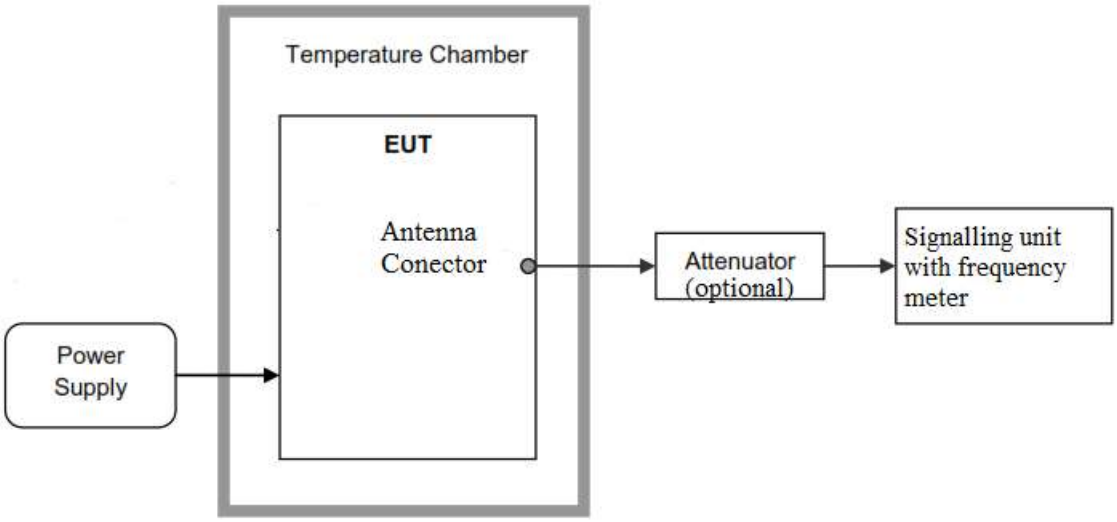
The EUT was set on the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst-case NBIoT mode for conducted power was used for the test.

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

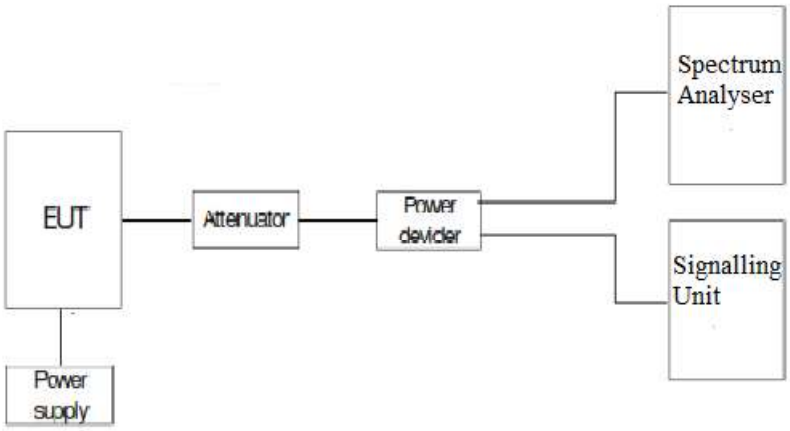
The reference point measurements were made at the RF output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

Test setup

Frequency tolerance:



Reference points *f*L and *f*H:



Results

NBIoT Band 12. π/4 - QPSK modulation. 3 tones 15 kHz, Offset Tone = 6. Channel: 707.5 MHz.

1. FREQUENCY TOLERANCE

- **Frequency stability over temperature variations.**

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+50	-6.57	-0.009286219
+40	32.29	0.045639576
+30	-1.54	-0.002176678
+20	-2.52	-0.003561837
+10	-1.42	-0.002007067
0	-2.76	-0.003901060
-10	-4.13	-0.005837456
-20	-6.52	-0.009215548
-30	-6.74	-0.009526502

- **Frequency stability over voltage variations.**

Battery Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	3.795	-1.97	-0.002784452
Vmin	2.805	-2.52	-0.003561837

2. REFERENCE FREQUENCY POINTS fL AND fH

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

***f*L (MHz)**	699.037260
***f*H (MHz)**	715.966265

The reference frequency points fL and fH stay within the authorized blocks.

Verdict

Pass

NBIoT Band 13. π/4 - QPSK modulation. 3 tones 15 kHz, Offset Tone = 6. Channel: 782 MHz.

1. FREQUENCY TOLERANCE

- **Frequency stability over temperature variations.**

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+50	-4.65	-0.005946292
+40	-4.65	-0.005946292
+30	-3.39	-0.004335038
+20	-2.25	-0.002877238
+10	-1.14	-0.001457801
0	-4.06	-0.005191816
-10	-4.03	-0.005153453
-20	-4.58	-0.005856777
-30	-4.92	-0.006291560

- **Frequency stability over voltage variations.**

Battery Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	3.795	-1.75	-0.002237852
Vmin	2.805	0.70	0.000895141

2. REFERENCE FREQUENCY POINTS fL AND fH

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

***f*L (MHz)**	777.033495
***f*H (MHz)**	786.971400

The reference frequency points fL and fH stay within the authorized blocks.

Verdict

Pass

NBIoT Band 66. π/4 - QPSK modulation. 3 tones 15 kHz, Offset Tone = 6. Channel: 1745 MHz.

1. FREQUENCY TOLERANCE

- **Frequency stability over temperature variations.**

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+50	13.03	0.007467049
+40	-0.70	-0.000401146
+30	2.42	0.001386819
+20	3.71	0.002126074
+10	2.37	0.001358166
0	-0.56	-0.000320917
-10	-6.09	-0.003489971
-20	-7.37	-0.004223496
-30	-7.70	-0.004412607h

- **Frequency stability over voltage variations.**

Battery Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	3.795	3.96	0.002269341
Vmin	2.805	2.47	0.001415473

2. REFERENCE FREQUENCY POINTS fL AND fH

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

***f*L (MHz)**	1710.052610
***f*H (MHz)**	1779.951670

The reference frequency points fL and fH stay within the authorized blocks.

Verdict

Pass

Modulation Characteristics

Limits

FCC §2.1047.

RSS-130, Clause 4.2: Equipment certified under this standard shall employ digital modulation.

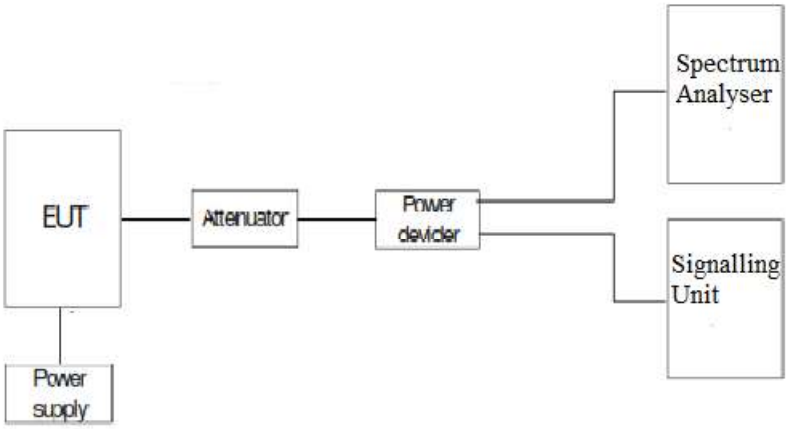
RSS-139, Clause 6.2: The devices may employ any type of modulation techniques. The type of modulation used must be reported.

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. The RF transmission is multiplexed using *Orthogonal Frequency Division Multiplexing (OFDM)* with different possible arrangement of subcarriers.

The EUT was set on the middle channel of each band using the Universal Radio Communication tester R&S CMW500 and the modulation scheme is displayed on the spectrum analyser.

Test setup

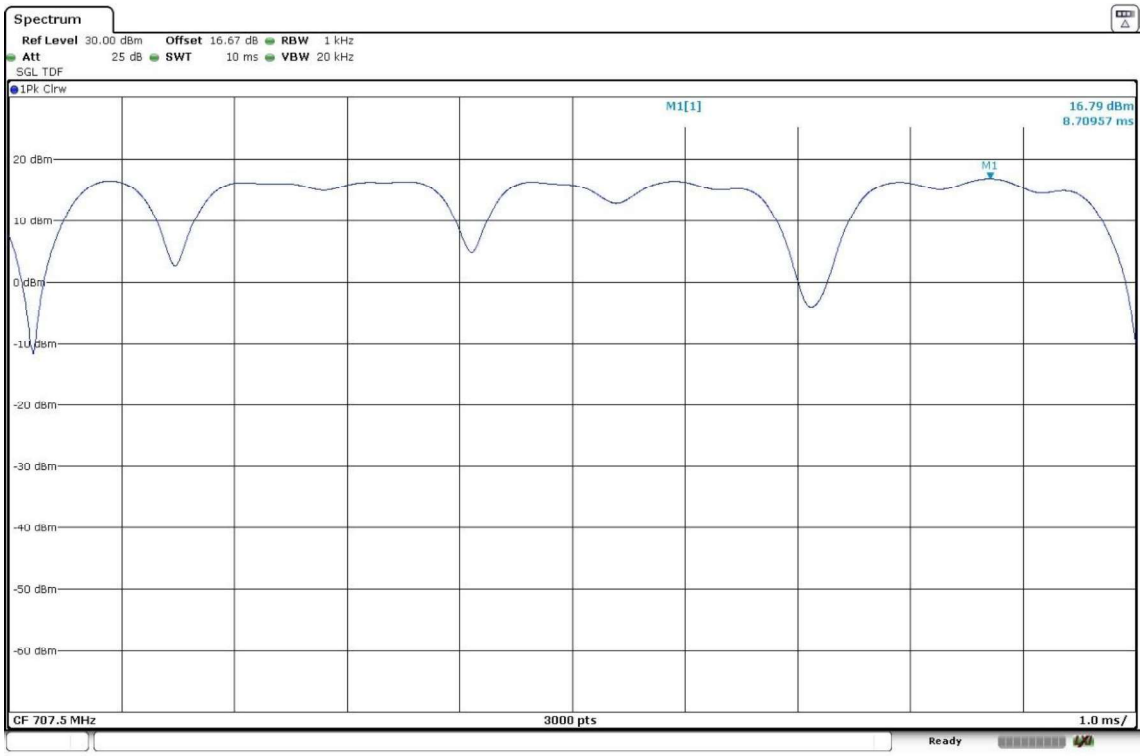


Results

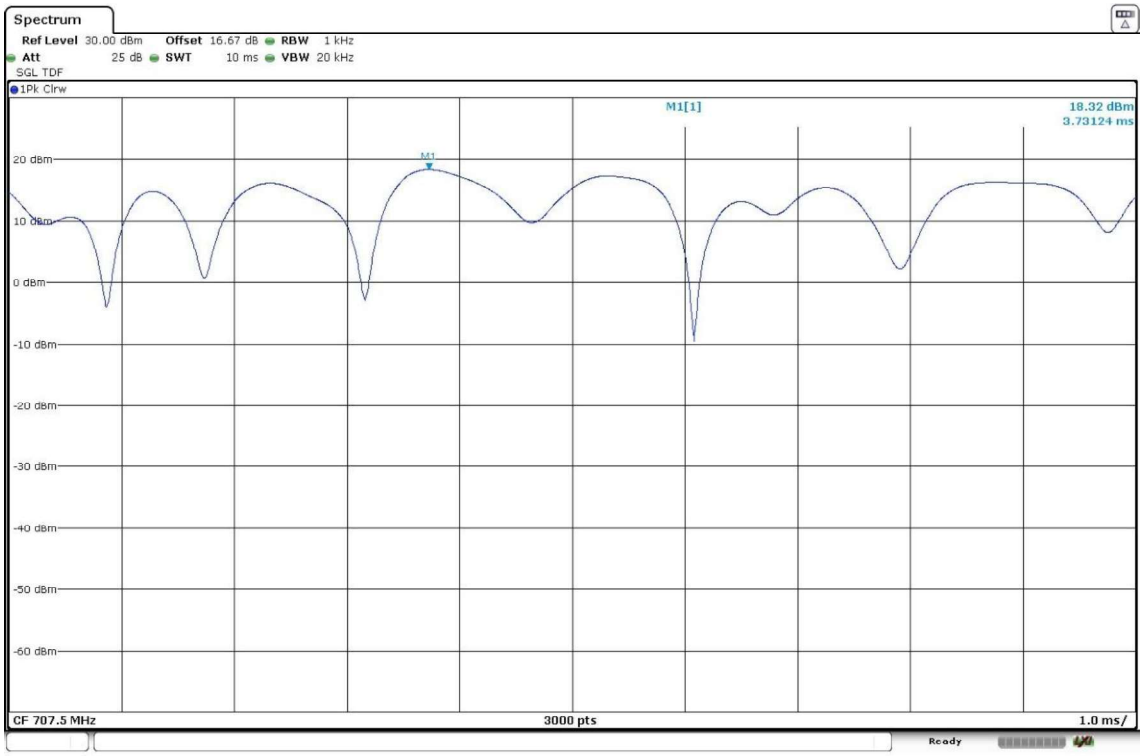
The following plots show the modulation schemes in the EUT.

NBIoT Band 12:

Modulation: π/2 – BPSK

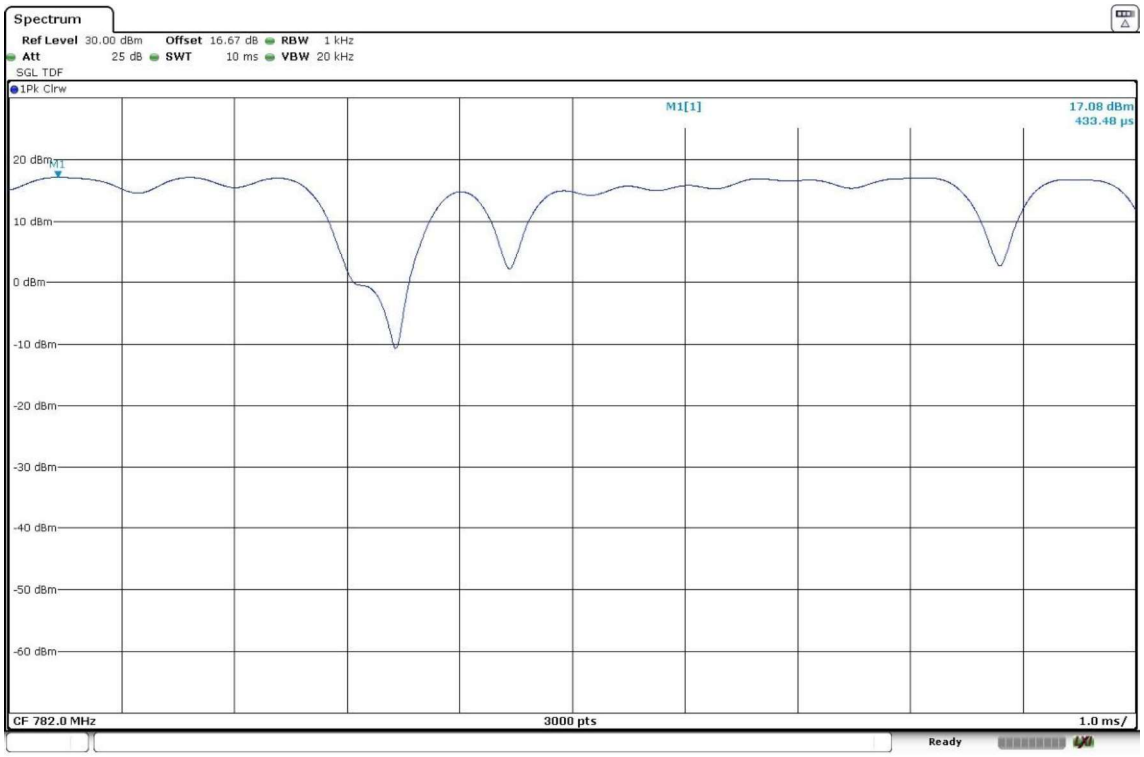


Modulation: π/4 - QPSK

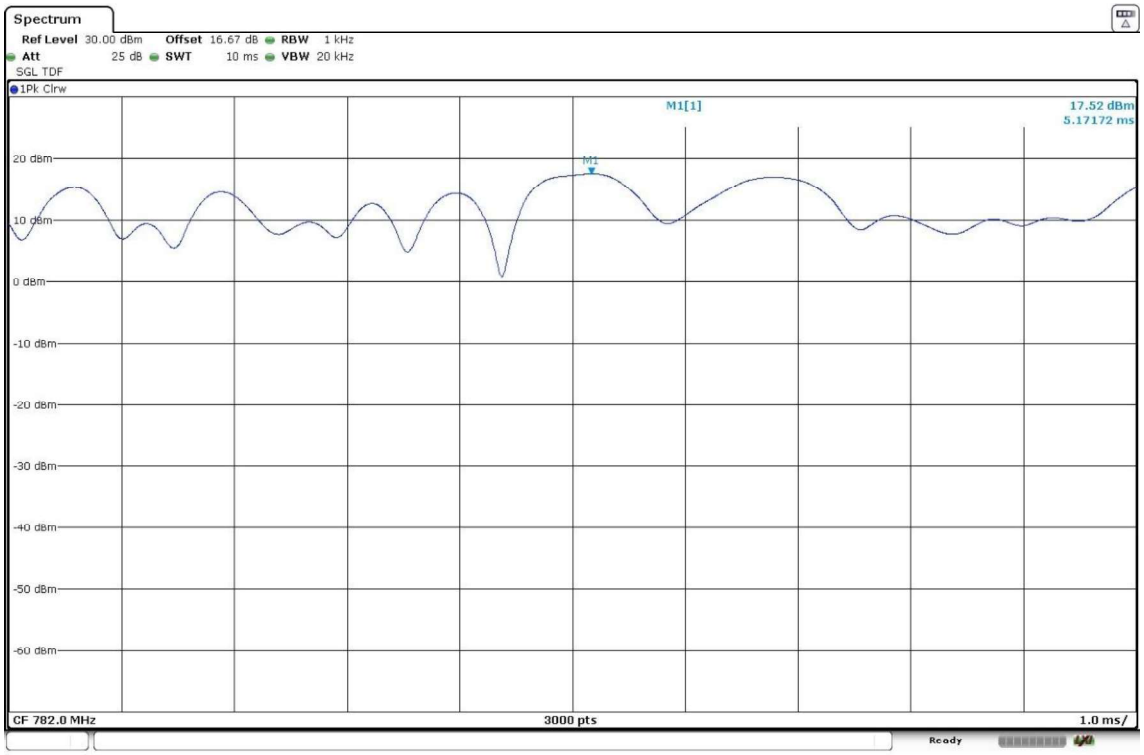


NBIoT Band 13:

Modulation: π/2 – BPSK

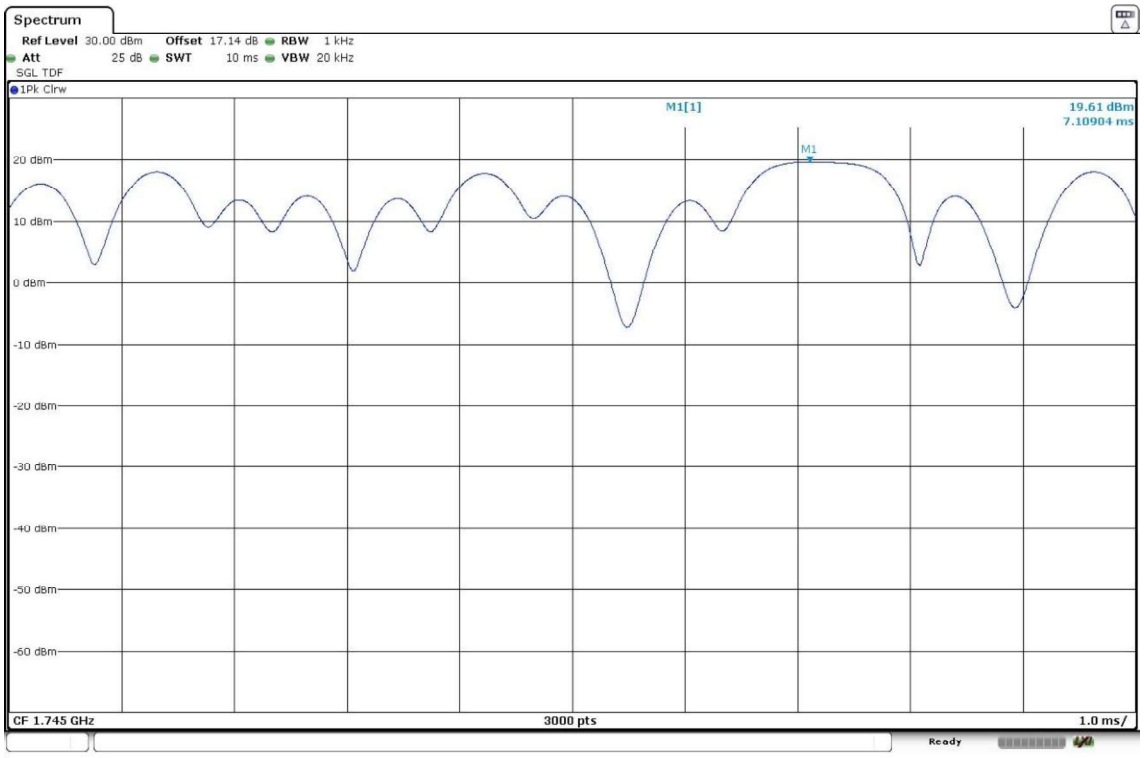


Modulation: π/4 – QPSK

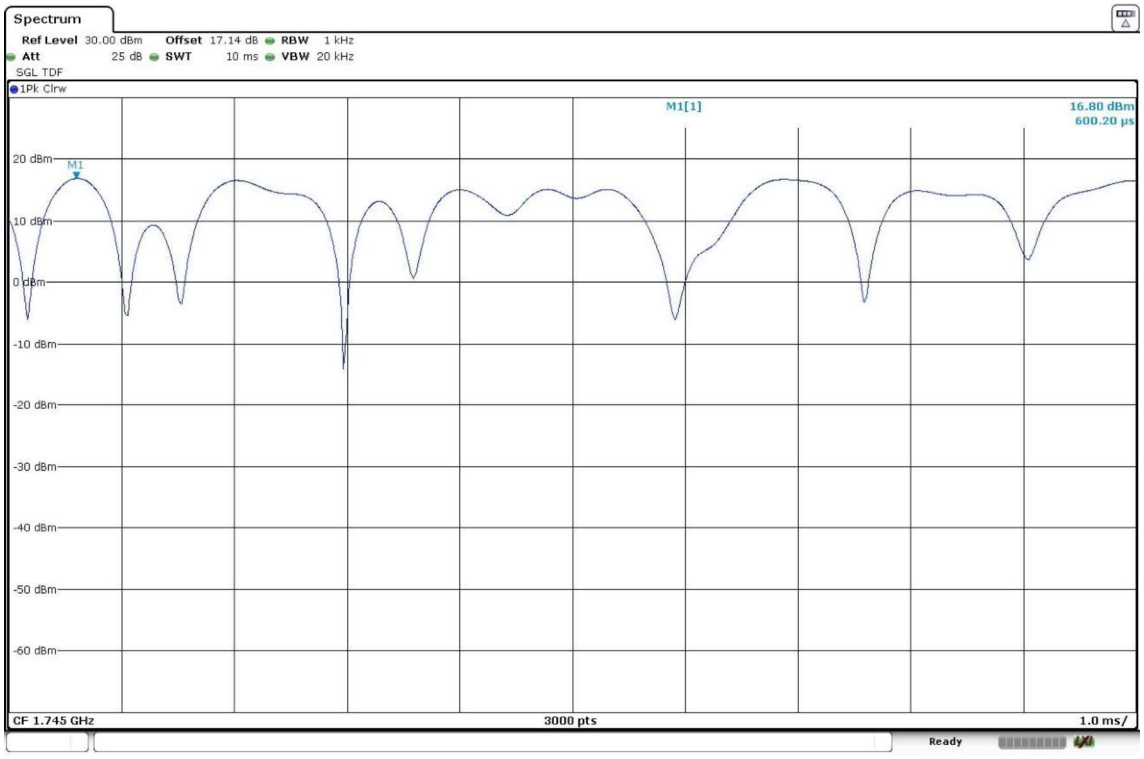


NBIoT Band 66:

Modulation: π/2 – BPSK



Modulation: π/4 – QPSK



Occupied Bandwidth

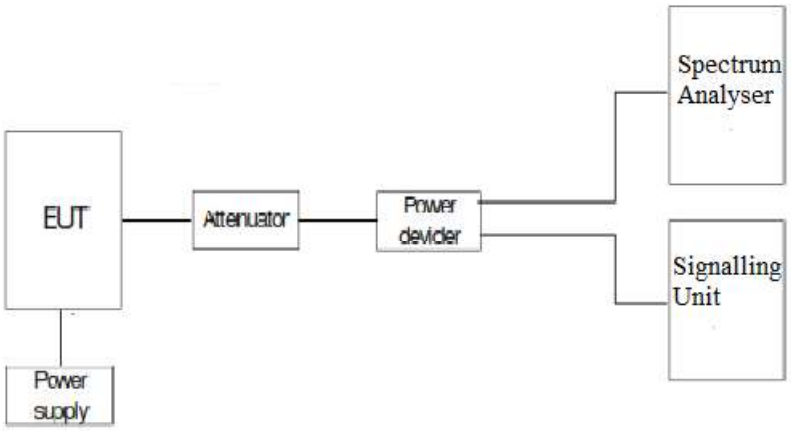
Limits

FCC §2.1049. Measurements required: Occupied bandwidth.

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 was measured directly using the built-in bandwidth measuring option of the spectrum analyser. The -26 dBc bandwidth was measured by setting a level line at 26 dB below the maximum measured carrier level.

Test setup



Results

NBIoT Band 12:

1 tone 3.75 kHz, π/2 - BPSK modulation.

Channel	99% Occupied Bandwidth (kHz)	-26 dBc Bandwidth (kHz)
Low	44.400000	35.034700
Middle	44.800000	34.986900
High	44.300000	34.977700

1 tone 3.75 kHz, π/4 - QPSK modulation.

Channel	99% Occupied Bandwidth (kHz)	-26 dBc Bandwidth (kHz)
Low	44.133333	41.083700
Middle	44.600000	40.934200
High	44.366667	37.811000

1 tone 15 kHz, π/2 - BPSK modulation.

Channel	99% Occupied Bandwidth (kHz)	-26 dBc Bandwidth (kHz)
Low	115.133333	131.035000
Middle	115.200000	133.416500
High	114.600000	131.387500

12 tones 15 kHz, π/4 - QPSK modulation.

Channel	99% Occupied Bandwidth (kHz)	-26 dBc Bandwidth (kHz)
Low	192.400000	292.963000
Middle	192.133333	292.715000
High	192.266667	291.153000

NBIoT Band 13:

1 tone 3.75 kHz, π/2 - BPSK modulation.

Channel	99% Occupied Bandwidth (kHz)	-26 dBc Bandwidth (kHz)
Low	44.800000	35.015500
Middle	44.500000	35.049000
High	44.900000	35.063200

1 tone 3.75 kHz, π/4 - QPSK modulation.

Channel	99% Occupied Bandwidth (kHz)	-26 dBc Bandwidth (kHz)
Low	44.333333	40.929300
Middle	44.633333	40.838900
High	44.833333	34.629900

1 tone 15 kHz, π/2 - BPSK modulation.

Channel	99% Occupied Bandwidth (kHz)	-26 dBc Bandwidth (kHz)
Low	115.000000	133.540400
Middle	114.933333	143.539100
High	115.200000	131.235100

12 tones 15 kHz, π/4 - QPSK modulation.

Channel	99% Occupied Bandwidth (kHz)	-26 dBc Bandwidth (kHz)
Low	191.946667	280.378000
Middle	194.640000	309.059000
High	194.293333	306.970000

NBIoT Band 66:

1 tone 3.75 kHz, π/2 - BPSK modulation.

Channel	99% Occupied Bandwidth (kHz)	-26 dBc Bandwidth (kHz)
Low	44.000000	34.964000
Middle	44.700000	35.039000
High	44.800000	34.868000

1 tone 3.75 kHz, π/4 - QPSK modulation.

Channel	99% Occupied Bandwidth (kHz)	-26 dBc Bandwidth (kHz)
Low	42.366667	40.902000
Middle	45.333333	40.620000
High	44.466667	37.547000

1 tone 15 kHz, π/2 - BPSK modulation.

Channel	99% Occupied Bandwidth (kHz)	-26 dBc Bandwidth (kHz)
Low	115.400000	133.286000
Middle	115.400000	133.408000
High	115.800000	133.553000

12 tones 15 kHz, π/4 - QPSK modulation.

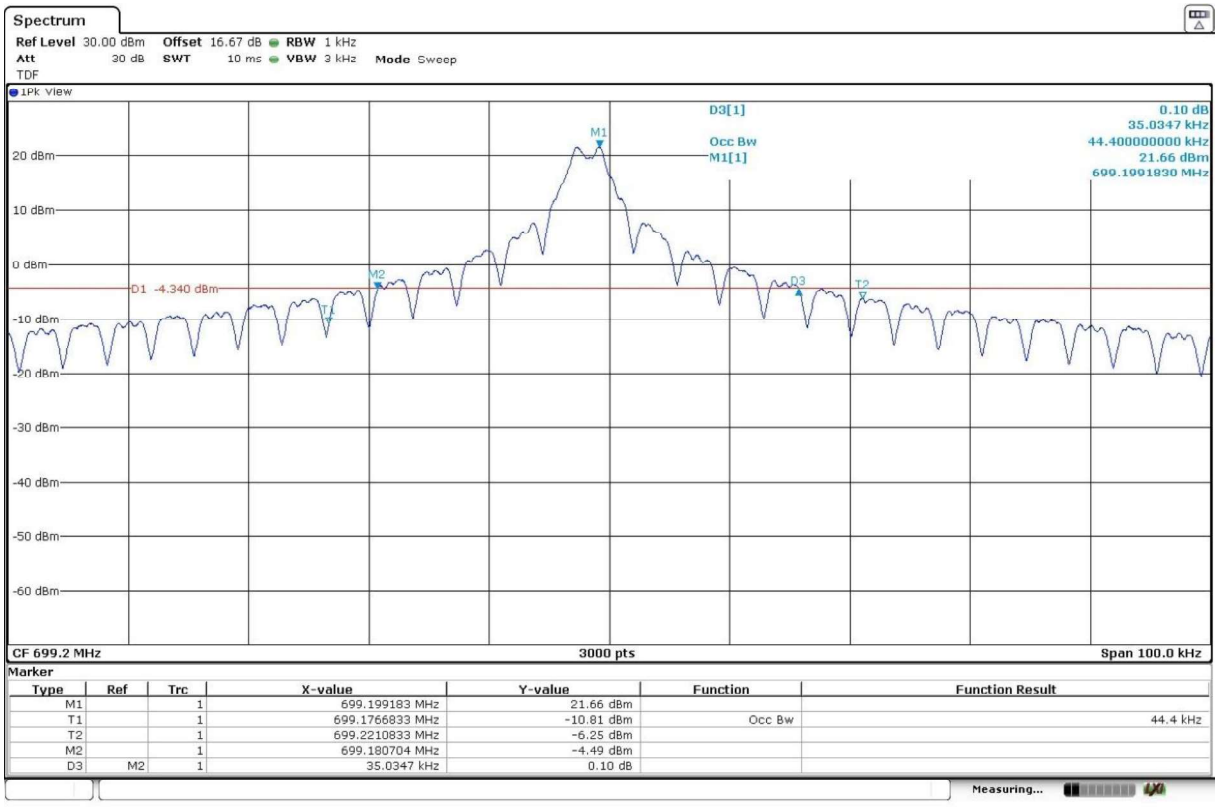
Channel	99% Occupied Bandwidth (kHz)	-26 dBc Bandwidth (kHz)
Low	194.533333	265.670000
Middle	194.400000	293.410000
High	193.600000	292.200000

Attachments

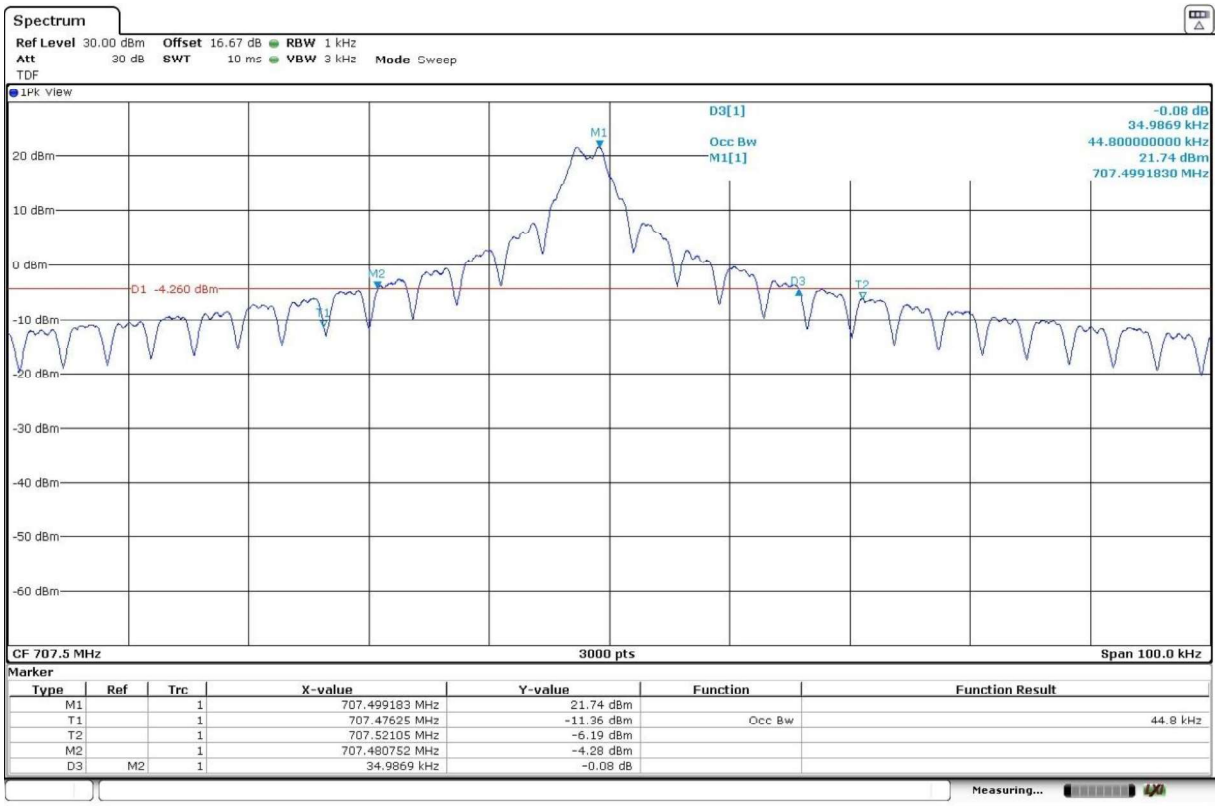
NBIoT Band 12.

1 tone 3.75 kHz, π/2 - BPSK modulation.

- Low Channel:



- Middle Channel:



- High Channel: