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

Test Report No:
72148RRF.001A3

Test Report
USA FCC Part 27

(*) Identification of item tested	nRF91
(*) Trademark	nRF91
(*) Model and /or type reference	nrRF9160
Other identification of the product	FCC ID: 2ANPO00NRF9160 IC: 24529-NRF9160
(*) Features	Features: LTE Cat-M1, LTE-NB1 HW version: nRF9160-SICA-B1A SW version: mfw_nRF9160_1.3.2
Applicant	NORDIC SEMICONDUCTOR ASA Otto Nielsens Vei 12 7052 Trondheim, Norway
Test method requested, standard	USA FCC Part 27 (10-1-21 Edition). ANSI C63.26-2015. ANSI/TIA-603-E: 2016. KDB 971168 D01 Power Meas License Digital Systems v03r01, April. 2018.
Summary	IN COMPLIANCE
Approved by (name / position & signature)	José Manuel Gómez Galván EMC Consumer & RF Lab. Manager Firmado digitalmente por 53680346W JOSE MANUEL GOMEZ (C:A29507456)
Date of issue	2023-05-31
Report template No	FDT08_24 (*) "Data provided by the client"

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Uncertainty

Uncertainty (factor k=2) was calculated according to the DEKRA Testing and Certification S.A.U. 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 of the model nRF91 consist in a Development Kit that has nRF9160 IOT Module and nRF52840 BTLE SoC. The nRF9160 is capable of LTE Cat-M1, Cat-NB1 and GPS. The Development kit has LTE, GPS and BTLE Antennas included.

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 & S/02	72148_1.1	Development Kit	nRF9160	351358811330114	2022-05-10	Element Under Test
S/02	72148_4.1	SMA cable	--	--	2022-05-10	Auxiliary Element

Notes referenced to samples during the project:

Id	Type
S/01	Sample used for radiated test
S/02	Sample used for conducted test

Test sample description

Ports……:	Port name and description	Cable					
		Specified max length [m]	Attached during test	Shielded	Coupled to patient(3)		
	LTE RF	2	☒	☒	☐		
	GPS	2	☐	☐	☐		
	BTLE		☐	☐	☐		
	--		☐	☐	☐		
Supplementary information to the ports…… :	-						
Rated power supply ..... :	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☐	☐
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC: 3.0 - 5.5 V					
	☐	DC:					
Rated Power..... :	1W						
Clock frequencies..... :	32KHz, 32MHz						
Other parameters ..... :	-						
Software version..... :	mfw_nRF9160_1.3.2						
Hardware version ..... :	nRF9160-SICA-B1A						
Dimensions in cm (W x H x D) ... :	15.5x6.4x0.9						
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	
	-						
	-						
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

NORDIC SEMICONDUCTOR ASA
Otto Nielsens Vei 12
7052 Trondheim, Norway

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2022-08-29
Date (finish)	2022-01-25

Document history

Report number	Date	Description
72148RRF.001	2022-11-08	First release.
72148RRF.001A1	2023-02-14	It includes conducted testing. This modification test report cancels and replaces the test report 72148RRF.001.
72148RRF.001A2	2023-03-29	It has been corrected some minor typos This modification test report cancels and replaces the test report 72148RRF.001A1.
72148RRF.001A3	2023-05-31	It has been corrected the lowest and highest frequency channels for NBIoT. This modification test report cancels and replaces the test report 72148RRF.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 %

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 %

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: Miguel Manuel López, Rafael Fernandez, Francisco Javier Fernández and Pablo Redondo.

Used instrumentation:

Control No.	Equipment	Model	Manufacturer	Next Calibration
6791	SEMIANECHOIC ABSORBER LINED CHAMBER IV	FACT 3 200 STP	ETS LINDGREN	N/A
6792	SHIELDED ROOM	S101	ETS LINDGREN	N/A
7817	EMI TEST RECEIVER 2Hz-44GHz	ESW44	ROHDE AND SCHWARZ	2023-12-30
6496	HORN ANTENNA 1-18GHz	BBHA 9120 D	SCHWARZBECK	2023-08-24
6143	HYBRID BILOG ANTENNA 30MHz-6GHz	3142E	ETS LINDGREN	2023-10-29
3783	PRE-AMPLIFIER G>30dB 1GHz-18GHz	BLMA 0118-3A	BONN ELEKTRONIK	2023-12-29
7445	DC POWER SUPPLY 30V/5A	U8002A	KEYSIGHT TECHNOLOGIES	N/A
7760	DIGITAL MULTIMETER	175	FLUKE	2023-11-14
4848	SOFTWARE FOR EMC/RF TESTING	EMC32	ROHDE AND SCHWARZ	N/A
7794	SIGNAL AND SPECTRUM ANALYZER 10Hz-40GHz	FSV40	ROHDE AND SCHWARZ	2025-04-21
5393	SIGNAL ANALYSER 20Hz-8GHz	FSQ8	ROHDE AND SCHWARZ	2023-11-03
6667	WIDEBAND RADIO COMMUNICATION TESTER	CMW500	ROHDE AND SCHWARZ	2023-05-31

Testing verdicts

Fail	F
Inconclusive	I
Not applicable	N/A
Not measured	N/M
Pass	P

Summary

FCC PART 27 PARAGRAPH		
Requirement – Test case	**Verdict**	**Remark**
FCC 27.1507: RF Output Power	P	--
FCC 2.1047: Modulation Characteristics	P	--
FCC 27.54: Frequency Stability	P	--
FCC 2.1049: Occupied Bandwidth	P	--
FCC 27.1509: Spurious Emissions at Antenna Terminals	P	--
FCC 27.1509: Spurious emissions at antenna terminals at Block Edges	P	--
FCC 27.1509: Radiated Emissions	P	--
Supplementary information and remarks: None.		

Appendix A: Test results for FCC 27

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TEST CONDITIONS

(*): Data provided the Applicant.

POWER SUPPLY (*):

Vnominal: 5Vdc

Vmin: 3Vdc

Vmax: 5.5Vdc

Type of Power Supply: DC external supply.

ANTENNA (*):

BAND	GAIN	ANTENNA TYPE
LTE Cat. M1 Band 8	+2.7 dBi	SMD
LTE NB-IoT Band 8	+2.7 dBi	SMD

TEST FREQUENCIES (*):

Operating broadband system: 897.5-900.5 MHz

LTE Cat M1 Band 8: QPSK and 16QAM Modulation:

	Channel per Nominal Bandwidth (Frequency MHz)			
	BW = 1.4 MHz	BW = 3 MHz	BW = 5 MHz	BW = 10 MHz
Low	21632 (898.2)			
Middle	21645 (899.5)			
High	21648 (899.8)			

LTE NB-IoT Band 8. Pi/2-BPSK and pi/4-QPSK Modulation:

	Channel Number (Frequency MHz)	
	Tone Channel BW = 3.75 kHz	Tone Channel BW = 15 kHz
Low	21628 (897.8)*	
Middle	21645 (899.5)	
High	21652 (900.2)*	
**The outermost channel which is in compliance with Block edge testing.*		

RF Output Power

SPECIFICATION:

FCC Subpart P §27.1507 (a):

(a) Maximum ERP. The power limits specified in this section are applicable to operations in areas more than 110 km (68.4 miles) from the U.S./Mexico border and 140 km (87 miles) from the U.S./Canada border.

(1) Mobile, control and auxiliary test stations. Mobile, control and auxiliary test stations must not exceed 10 watts ERP.
(2) Portable stations. Portable stations must not exceed 3 watts ERP.

(b) PAR limit. The peak-to-average ratio (PAR) of the transmission must 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:

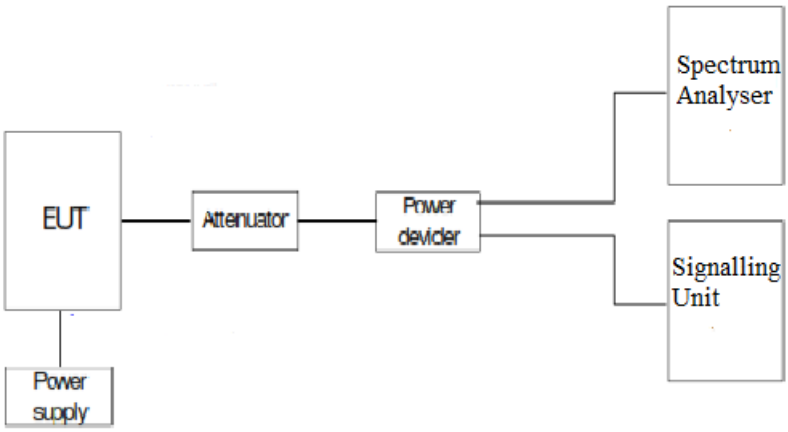
$$E.R.P. = E.I.R.P. – 2.15\ dB$$

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:

1. CONDUCTED AVERAGE POWER:

2. PEAK-TO-AVERAGE POWER RATIO (PAPR):



RESULTS:

1. AVERAGE POWER:

LTE Cat. M1 Band 8

Preliminary measurements determined the narrow band = 0 and nominal bandwidth of 1.4 MHz as the worst case. The results in the next tables shows the results for this configuration.

Narrow band = 0

BANDWIDTH (MHz)	CHANNEL	FREQUENCY (MHz)	MODULATION	RB SIZE	RB OFFSET	AVERAGE POWER (dBm)	PAPR (dB)
1.4	21632	898.2	QPSK	1 6	2 0	22.86 -	- -
			16-QAM	1 5	2 1	21.91 -	6.65 -
	21645	899.5	QPSK	1 6	2 0	22.94 21.04	5.14 5.67
			16-QAM	1 5	2 1	21.87 20.90	7.05 6.57
	21648	899.8	QPSK	1 6	2 0	22.90 -	- -
			16-QAM	1 5	2 1	21.92 -	6.68 -

Measurement uncertainty (dB): ±0.941

LTE Cat. M1 Band 8. QPSK MODULATION. Bandwidth = 1.4 MHz.

Channel	Lowest	Middle	Highest
Maximum declared antenna gain (dBi)	2.70	2.70	2.70
Measured maximum average power (dBm) at antenna port	22.86	22.94	22.90
Maximum equivalent isotropically radiated power E.I.R.P. (dBm)	25.56	25.64	25.60
Maximum effective radiated power E.R.P. (dBm)	23.41	23.49	23.45
PAPR (dB)	(*)	5.67	(*)
Measurement uncertainty (dB)	±0.941		

Worst case AVERAGE POWER: Modulation QPSK. RB Size: 1. RB Offset: 2.

Worst case PAPR: Modulation QPSK. RB Size: 6. RB Offset: 0.

(*): Preliminary measurements determined the Middle Channel as the worst case.

LTE Cat. M1 Band 8. 16QAM MODULATION. Bandwidth = 1.4 MHz.

Channel	Lowest	Middle	Highest
Maximum declared antenna gain (dBi)	2.70	2.70	2.70
Measured maximum average power (dBm) at antenna port	21.91	21.87	21.92
Maximum equivalent isotropically radiated power E.I.R.P. (dBm)	24.61	24.57	24.62
Maximum effective radiated power E.R.P. (dBm)	22.46	22.42	22.47
PAPR (dB)	6.65	7.05	6.68
Measurement uncertainty (dB)	±0.941		

Worst case AVERAGE POWER: Modulation 16QAM. RB Size: 1. RB Offset: 2.
Worst case PAPR: Modulation 16QAM. RB Size: 1. RB Offset: 2.

Verdict: Pass

LTE NB-IoT Band 8

CHANNEL	FREQUENCY (MHz)	MODULATION	BW Tono	Number of Tone	Offset Tone (Start SubCarrier)	AVERAGE POWER (dBm)	PAPR (dB)
Low 21628	897.8	pi/2-BPSK	3.75 kHz	1	0	22.12	-
				1	47	-	-
			15 kHz	1	0	-	-
				1	11	-	-
		pi/4 - QPSK	3.75 kHz	1	0	-	-
				1	47	21.95	-
			15 kHz	1	0	-	-
				1	11	-	-
				3	0	-	-
				3	9	-	-
				6	0	-	-
				6	6	-	-
				12	0	-	4.42
Middle 21645	899.5	pi/2-BPSK	3.75 kHz	1	0	22.9	0.77
				1	47	22.71	0.72
			15 kHz	1	0	21.93	0.7
				1	11	21.91	0.67
		pi/4 - QPSK	3.75 kHz	1	0	22.65	0.91
				1	47	22.72	0.79
			15 kHz	1	0	21.93	0.94
				1	11	21.92	0.96
				3	0	22.54	3.88
				3	9	22.62	3.46
				6	0	21.78	4.76
				6	6	21.78	4.79
				12	0	20.8	5
High 21652	900.2	pi/2-BPSK	3.75 kHz	1	0	22.01	-
				1	47	-	-
			15 kHz	1	0	-	-
				1	11	-	-
		pi/4 - QPSK	3.75 kHz	1	0	-	-
				1	47	22.066	-
			15 kHz	1	0	-	-
				1	11	-	-
				3	0	-	-
				3	9	-	-
				6	0	-	-
				6	6	-	-
				12	0	-	4.29

Verdict: Pass

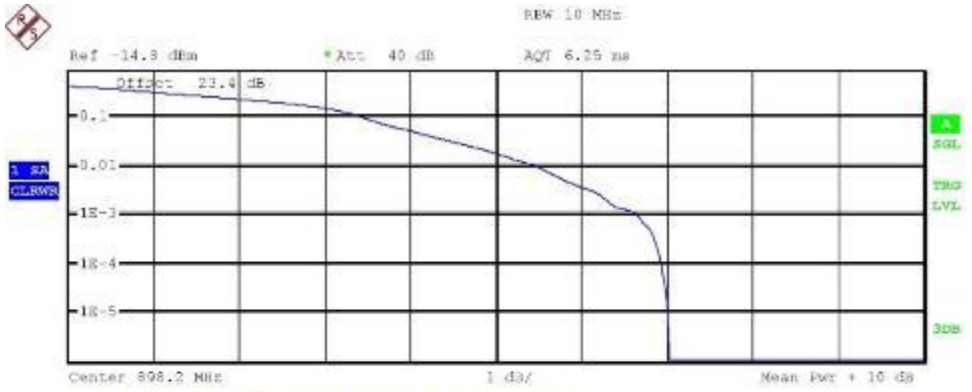
2. PEAK-TO-AVERAGE POWER RATIO (PAPR):

LTE Cat, M1 Band 8.

Preliminary measurements determined the narrow band = 0, nominal bandwidth of 1.4 MHz, 16-QAM modulation and 1 RB size offset 2 as the worst case. The results in the next tables shows the results for this configuration.

Bandwidth = 1.4 MHz. Modulation 16QAM. RB Size: 1. RB Offset: 2.

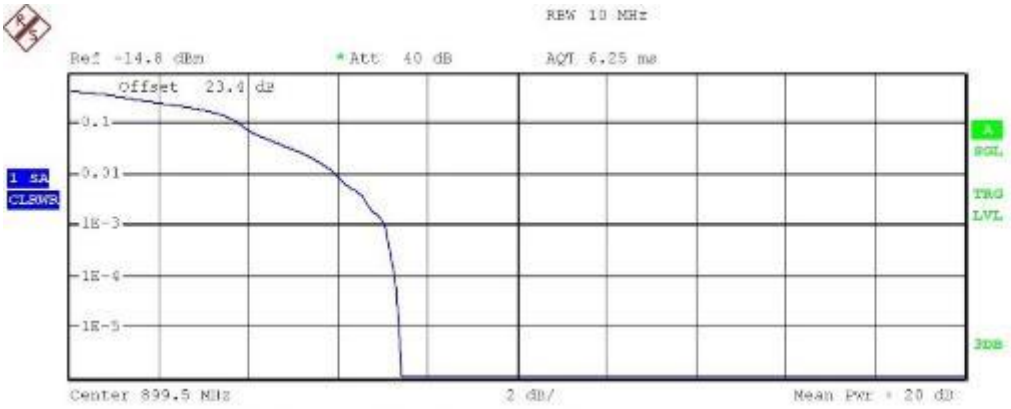
Lowest Channel:



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

	Trace 1
Mean	21.25 dBm
Peak	28.27 dBm
Crest	7.01 dB
10 %	3.48 dB
1 %	5.48 dB
.1 %	6.65 dB
.01 %	6.94 dB

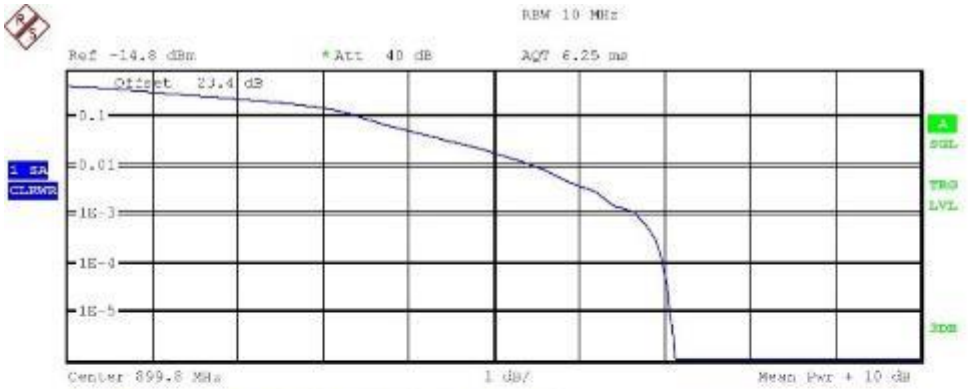
Middle Channel:



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

	Trace 1
Mean	21.33 dBm
Peak	28.74 dBm
Crest	7.40 dB
10 %	3.78 dB
1 %	5.96 dB
.1 %	7.05 dB
.01 %	7.28 dB

Highest Channel:



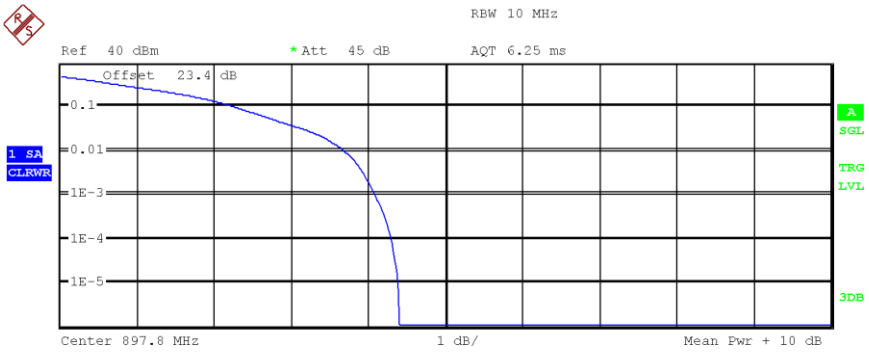
Complementary Cumulative Distribution Function
NOF samples: 100000, Usable BW: 11.2MHz

	Trace 1
Mean	21.22 dBm
Peak	28.34 dBm
Crest	7.12 dB
10 %	3.48 dB
1 %	5.50 dB
.1 %	6.68 dB
.01 %	6.99 dB

LTE NB-IoT Band 8

Preliminary measurements determined that pi/4-QPSK modulation, 12 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

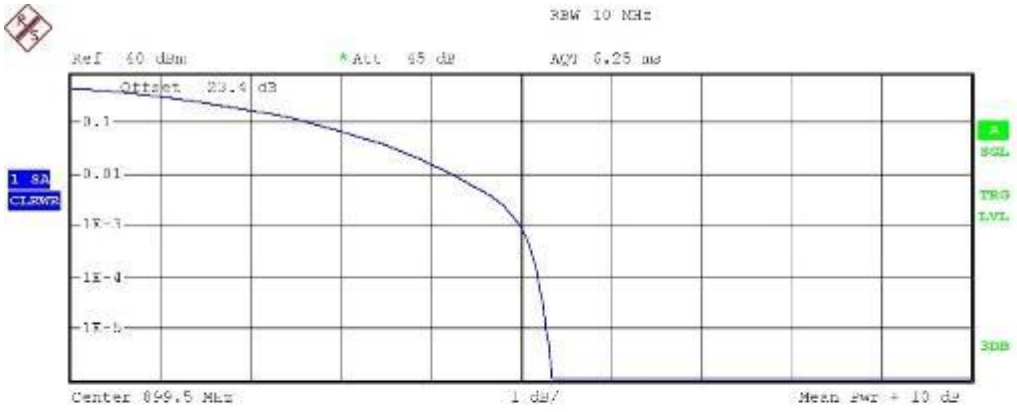
Lowest Channel:



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

	Trace 1
Mean	20.89 dBm
Peak	25.29 dBm
Crest	4.40 dB
10 %	2.28 dB
1 %	3.69 dB
.1 %	4.09 dB
.01 %	4.29 dB

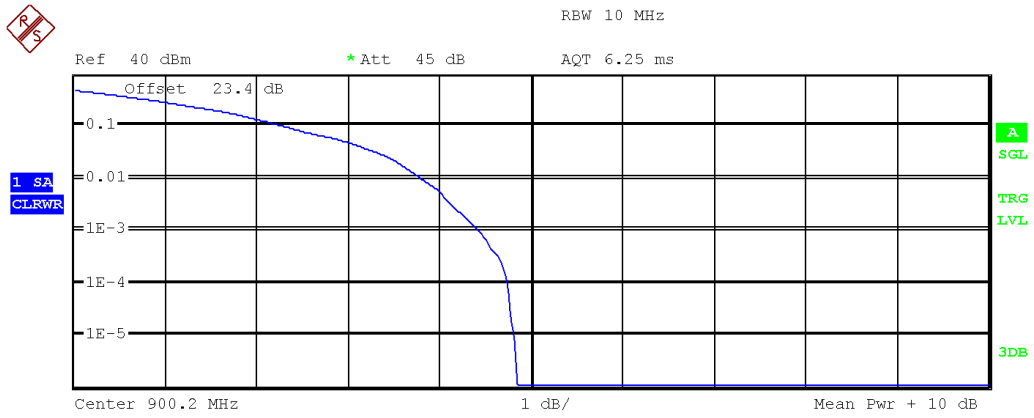
Middle Channel:



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

	Trace 1
Mean	20.98 dBm
Peak	26.32 dBm
Crest	5.35 dB
10 %	2.72 dB
1 %	4.26 dB
.1 %	5.00 dB
.01 %	5.19 dB

Highest Channel:



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

	Trace 1
Mean	20.66 dBm
Peak	25.50 dBm
Crest	4.84 dB
10 %	2.32 dB
1 %	3.80 dB
.1 %	4.42 dB
.01 %	4.74 dB

Frequency Stability

SPECIFICATION

FCC §2.1055.

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

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.

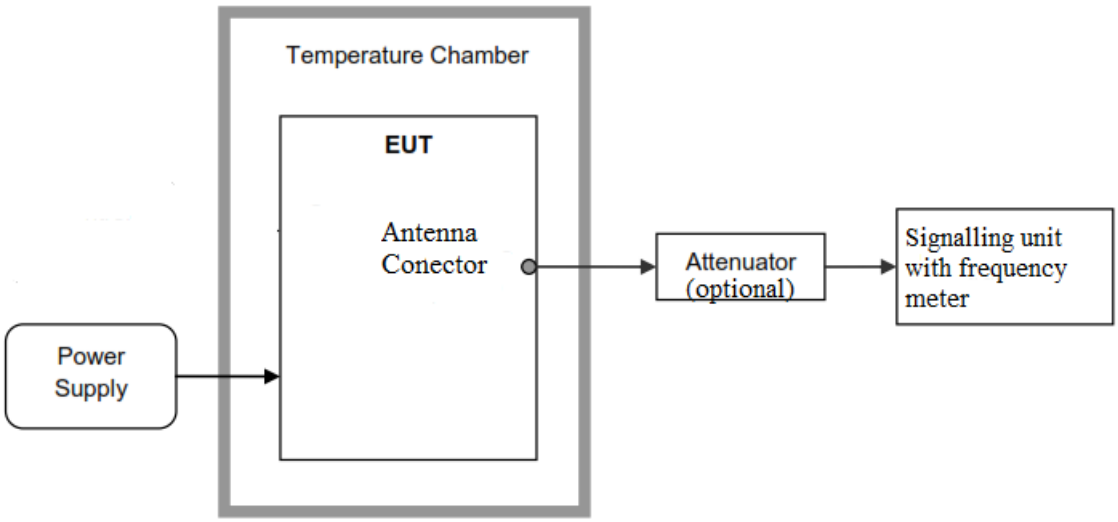
The EUT was set in “Radio Resource Control (RRC) mode” in the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case LTE mode for conducted power was used for the test.

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.

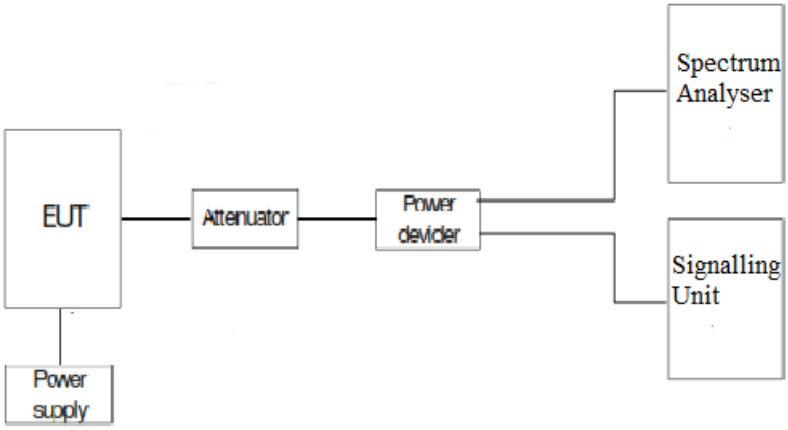
The reference point measurements were made at the RF output terminals of the EUT using an attenuator. power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

TEST SETUP

Frequency tolerance.



Reference points *f*L and *fH.*



RESULTS

Frequency stability over temperature variations.

LTE Cat. M1 Band 8:

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+50	5000	5.558643
+40	10000	11.11728
+30	3350	3.724291
+20	6700	7.448582
+10	6700	7.448582
0	11650	12.9516
-10	1650	1.834352
-20	10000	11.11728
-30	10000	11.11728

LTE NB-IoT Band 8:

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+50	-4,25	-0,004724847
+40	-1,61	-0,001789883
+30	-11,37	-0,012640356
+20	-3,51	-0,003902168
+10	11,91	0,013240689
0	12,61	0,014018899
-10	-6,5	-0,007226237
-20	-7,52	-0,0083602
-30	-6,23	-0,00692607

Frequency stability over voltage variations.

LTE Cat. M1 Band 8

Battery Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	11650	12.9516
Vmin	3	11650	12.9516

LTE NB-IoT Band 8

Battery Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	-7,26	-0,008071151
Vmin	3	-6,15	-0,006837132

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

	LTE Cat. M1 Band 8
*f*L (MHz)	897.5308
fH (MHz)	900.4879

	LTE NB-IoT Band 8
*f*L (MHz)	897,5396
fH (MHz)	900,4541

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

	LTE Cat. M1 Band 8
*f*L (MHz)	897.519125
fH (MHz)	900.499583

	LTE NB-IoT Band 8
*f*L (MHz)	897,5397
fH (MHz)	900,4541

The reference frequency points stay within the authorized blocks.

Verdict: Pass

Modulation Characteristics

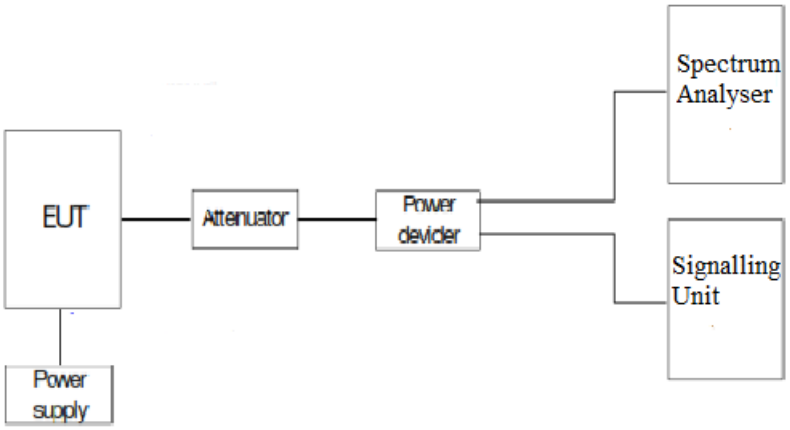
SPECIFICATION

FCC §2.1047

METHOD

For LTE the EUT operates with QPSK and 16QAM 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)* using different possible arrangement of subcarriers (Resource Blocks RB).

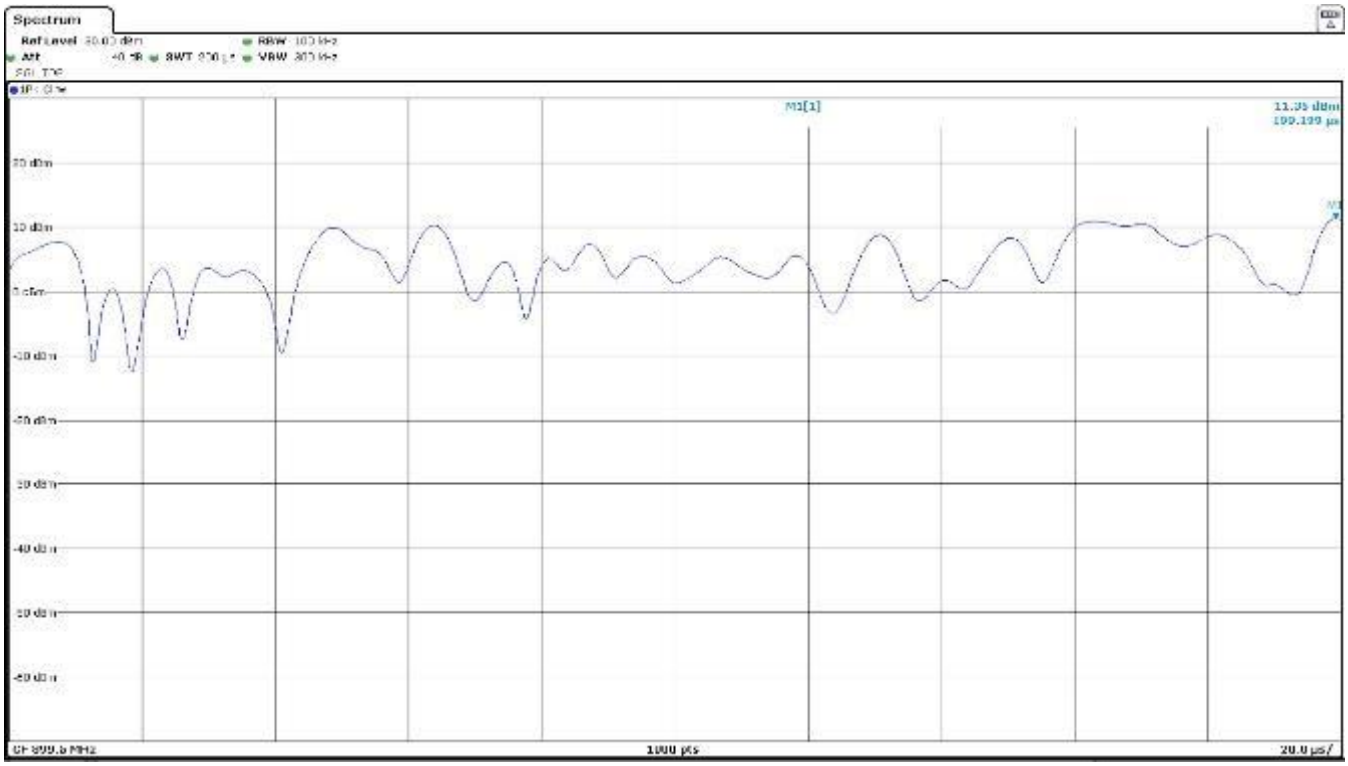
TEST SETUP



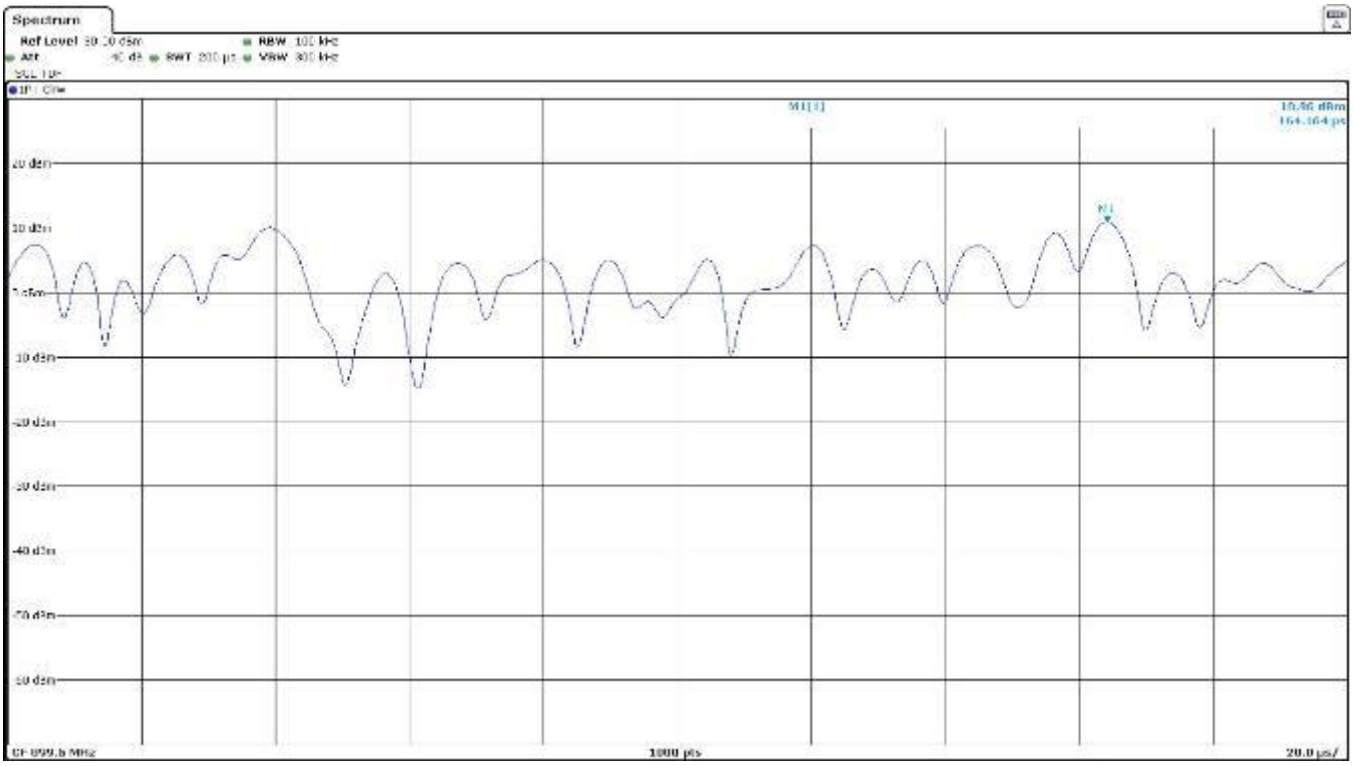
RESULTS

The following plot shows the modulation schemes in the EUT.

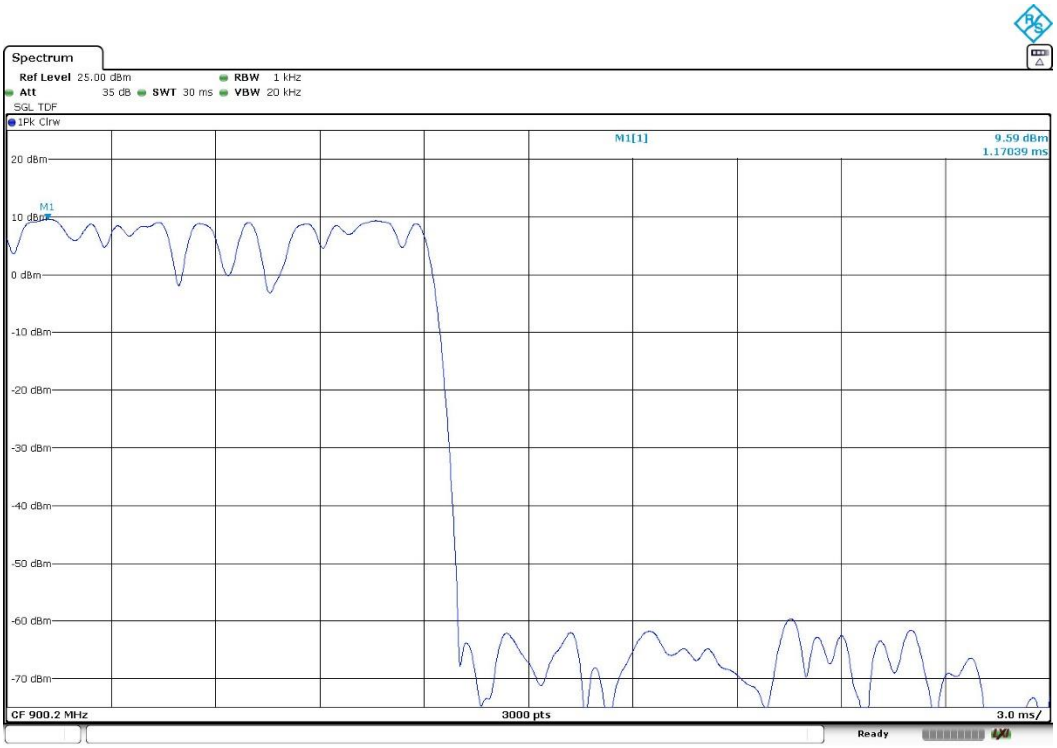
LTE Cat. M1 Band 8 modulation. QPSK.



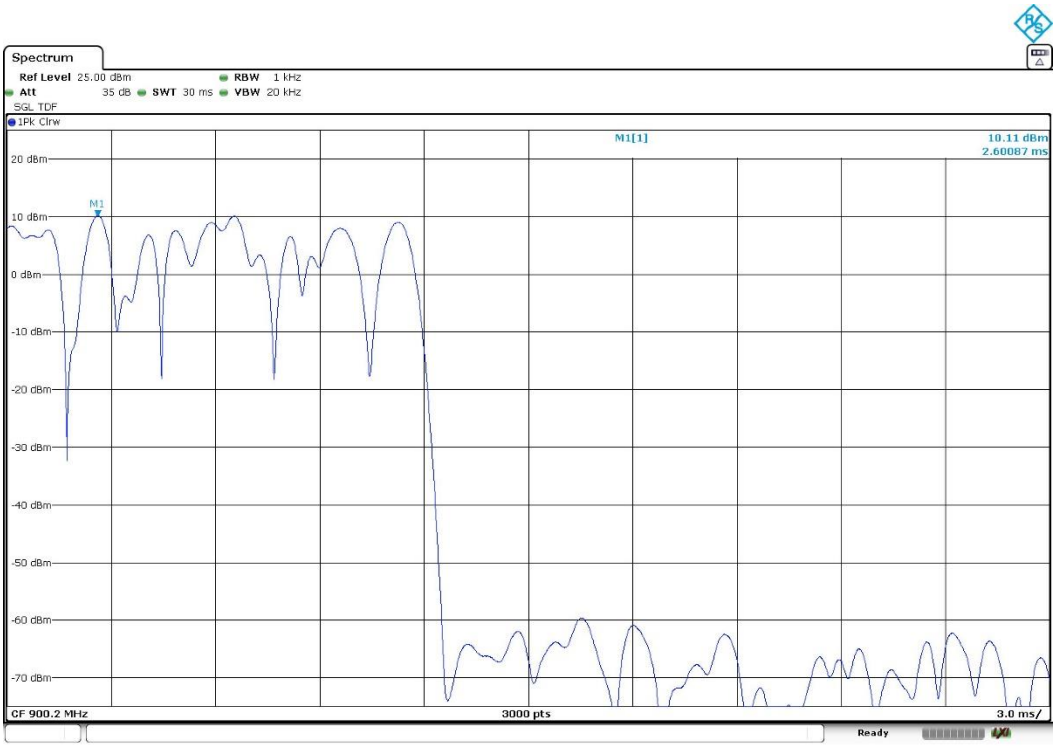
LTE Cat. M1 Band 8 modulation. 16QAM.



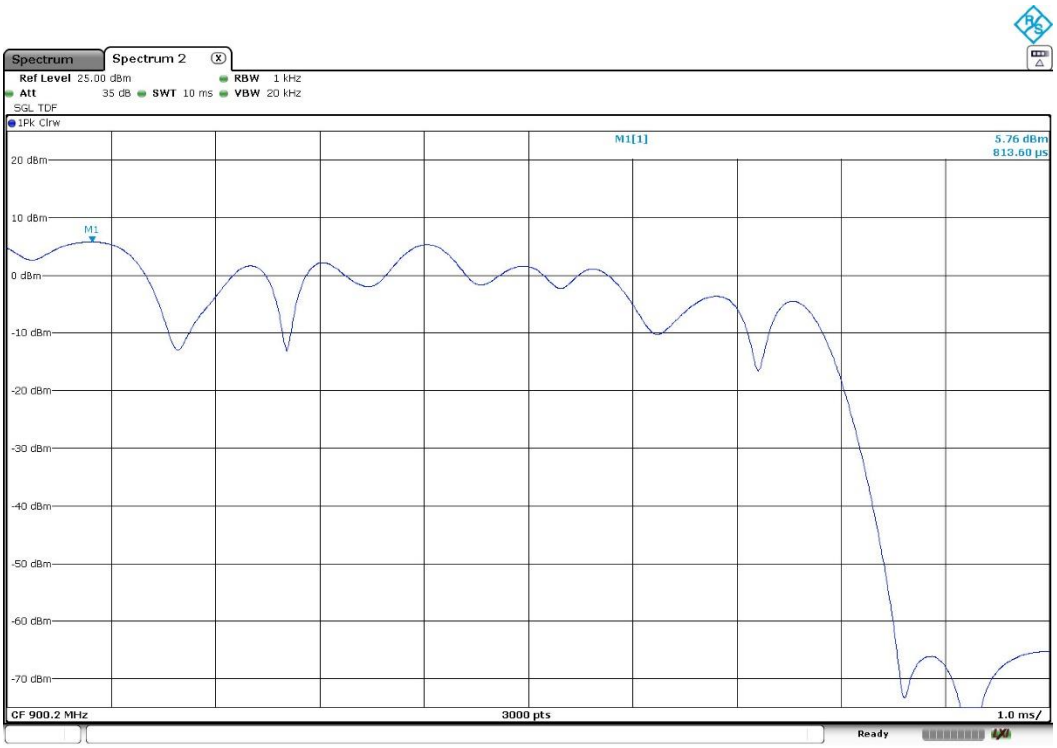
LTE NB-IoT Band 8 modulation. Pi/4-QPSK. 1 tone of 3.75kHz



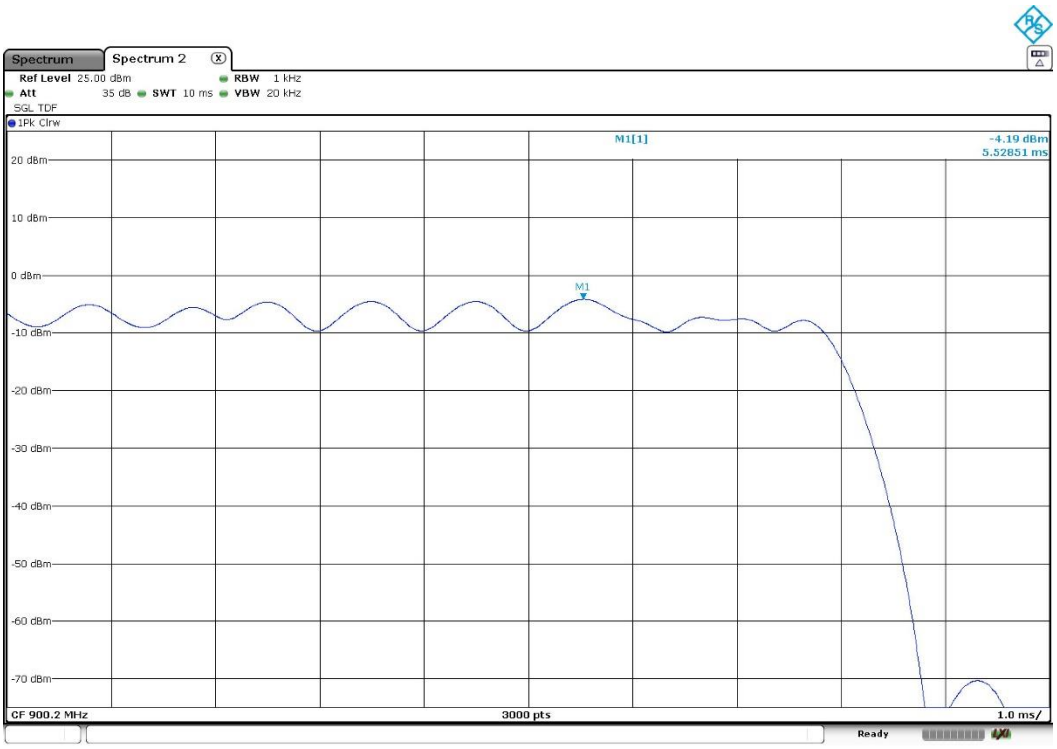
LTE NB-IoT Band 8 modulation. Pi/2-BPSK. 1 tone of 3.75kHz



LTE NB-IoT Band 8 modulation. Pi/2-BPSK. 1 tone 15kHz



LTE NB-IoT Band 8 modulation. Pi/2-BPSK. 12 tones 15kHz



Occupied Bandwidth

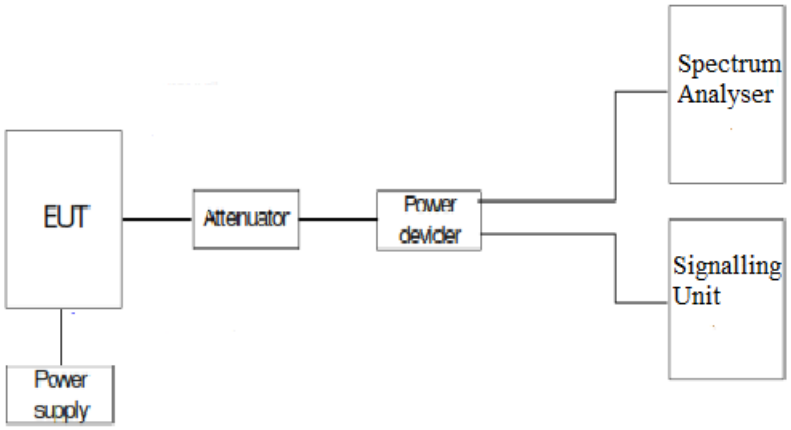
SPECIFICATION

§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)

The worst case of occupied bandwidth corresponds to all Resource Blocks (RB) offset 0 regardless either the Narrow band position or the nominal bandwidth selected.

LTE Cat. M1 QPSK MODULATION. BW = 1.4 MHz (Band 8). Narrow band: 0.

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (MHz)	1.111	1.113	1.109
-26 dBc bandwidth (MHz)	1.376	1.423	1.428
Measurement uncertainty (kHz)	<±5.20		

LTE Cat. M1 16QAM MODULATION. BW = 1.4 MHz (Band 8). Narrow band: 0.

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (MHz)	0.938	0.952	0.944
-26 dBc bandwidth (MHz)	1.304	1.316	1.291
Measurement uncertainty (kHz)	<±5.20		

LTE NB-IoT pi/4-QPSK MODULATION (Band 8). 1 tone of 3.75kHz, Offset= 0

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (KHz)	61,933	61,133	61,400
-26 dBc bandwidth (KHz)	41,882	41,701	41,739
Measurement uncertainty (kHz)	<±5.20		

LTE NB-IoT pi/2-BPSK MODULATION (Band 8). 1 tone of 3.75kHz, Offset= 0

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (KHz)	57,067	57,067	56,333
-26 dBc bandwidth (KHz)	41,215	40,834	41,139
Measurement uncertainty (kHz)	<±5.20		

LTE NB-IoT pi/4-QPSK MODULATION (Band 8). 12 tones of 15kHz, Offset= 0

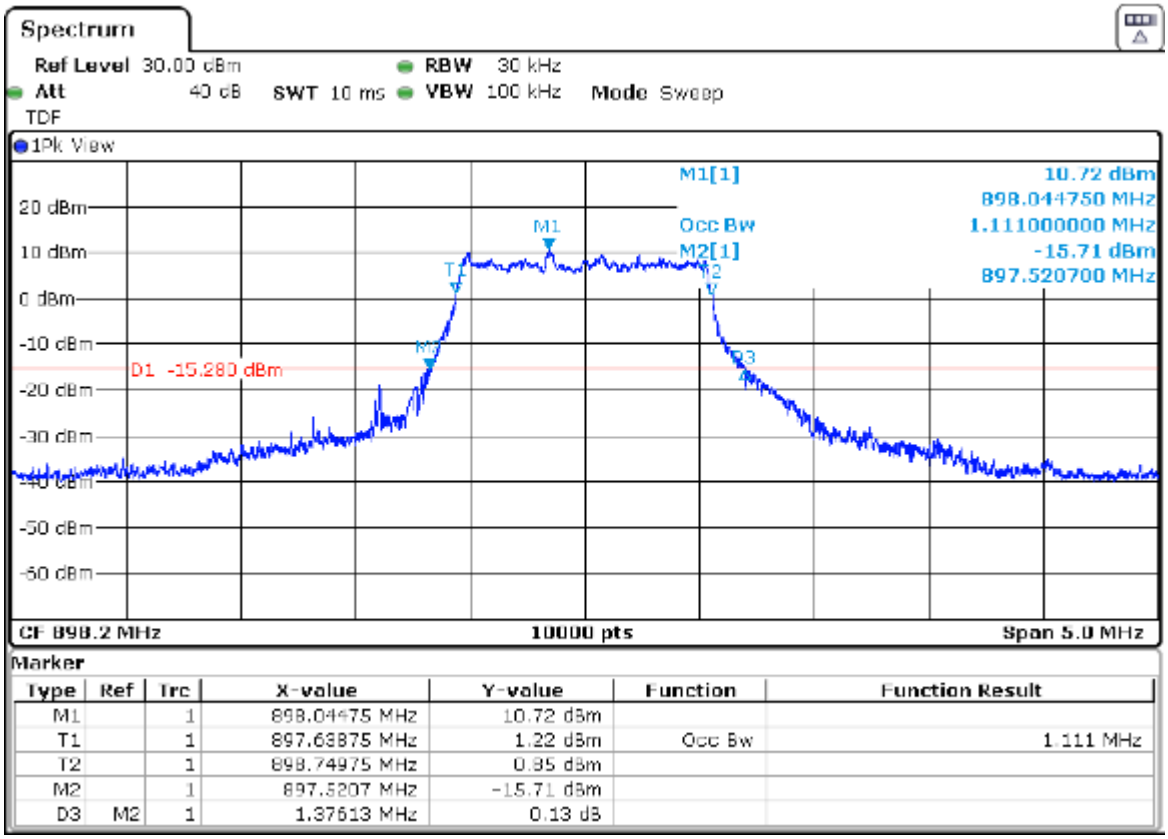
Channel	Lowest	Middle	Highest
99% Occupied bandwidth (KHz)	186,533	186,533	186,533
-26 dBc bandwidth (KHz)	288,450	289,230	288,450
Measurement uncertainty (kHz)	<±5.20		

LTE NB-IoT pi/2-BPSK MODULATION (Band 8). 1 tone of 15kHz, Offset= 11

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (KHz)	128,13333	127,33333	127,20000
-26 dBc bandwidth (KHz)	127,68000	127,10000	126,83000
Measurement uncertainty (kHz)	<±5.20		

LTE Cat. M1 QPSK MODULATION. BW = 1.4 MHz (Band 8)

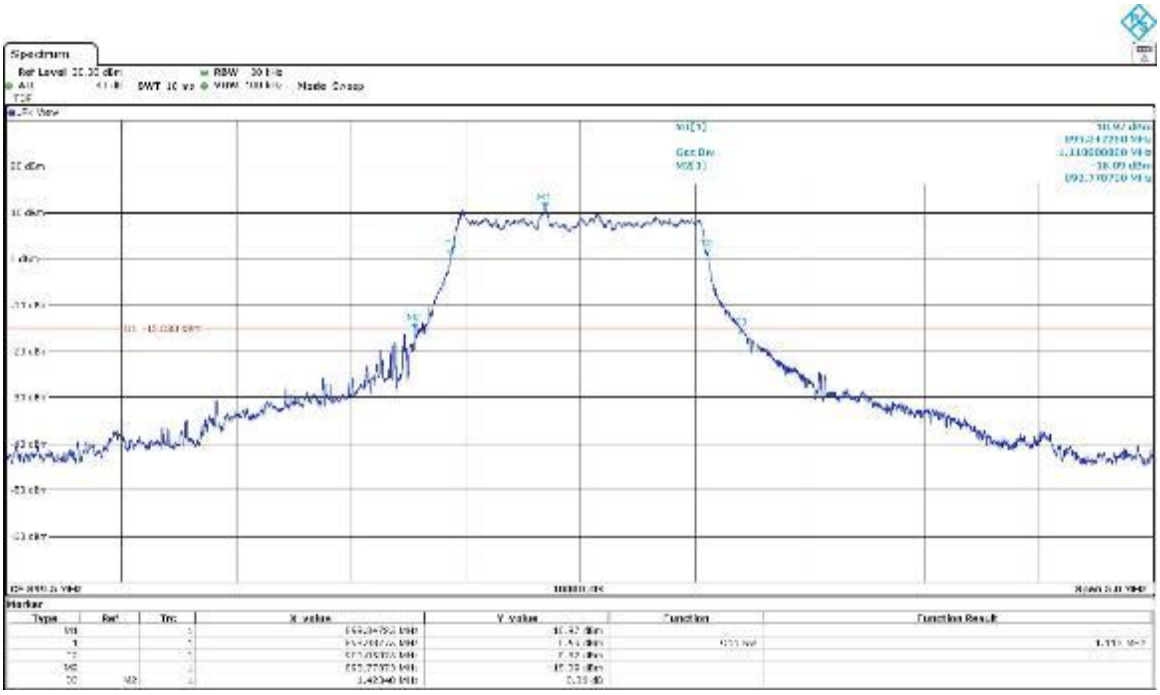
Lowest Channel



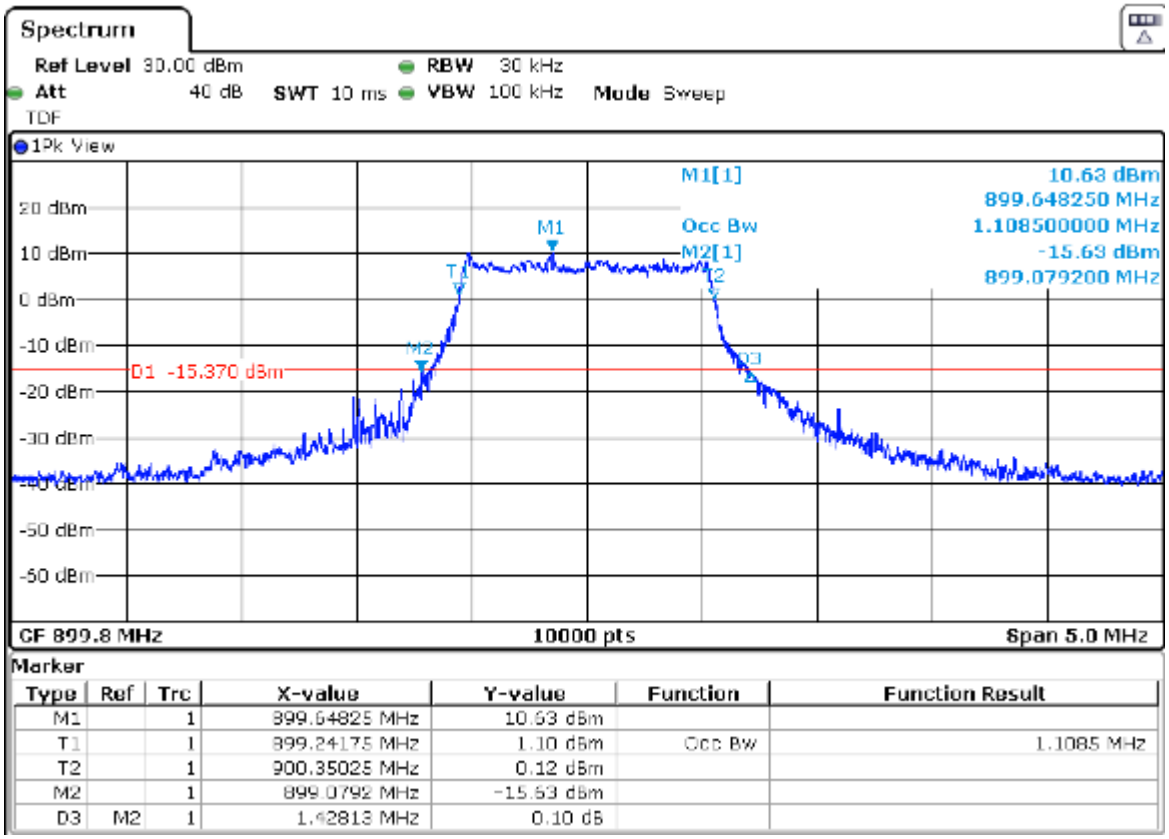
Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	898.04475 MHz	10.72 dBm		
T1		1	897.63875 MHz	1.22 dBm	Occ Bw	1.111 MHz
T2		1	898.74975 MHz	0.85 dBm		
M2		1	897.5207 MHz	-15.71 dBm		
D3	M2	1	1.37613 MHz	0.13 dB		

Middle Channel

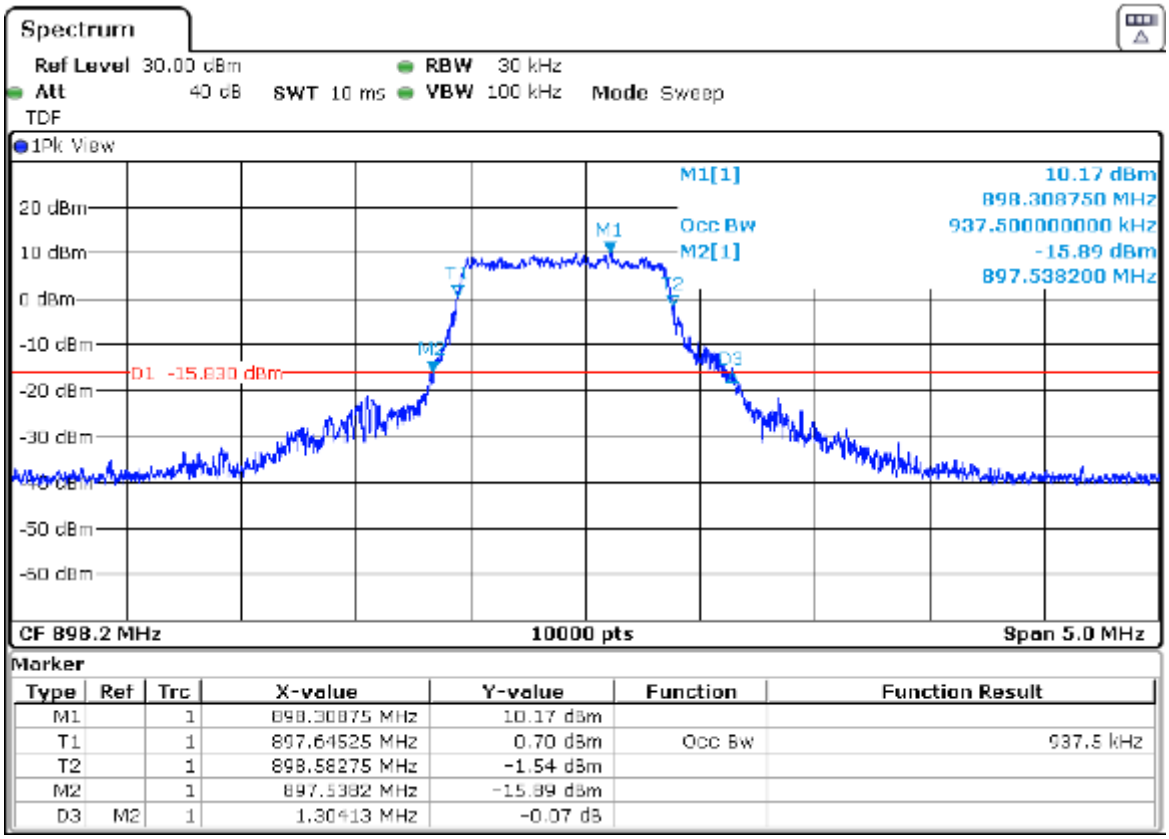


Highest Channel



LTE Cat. M1 16QAM MODULATION. BW = 1.4 MHz (Band 8)

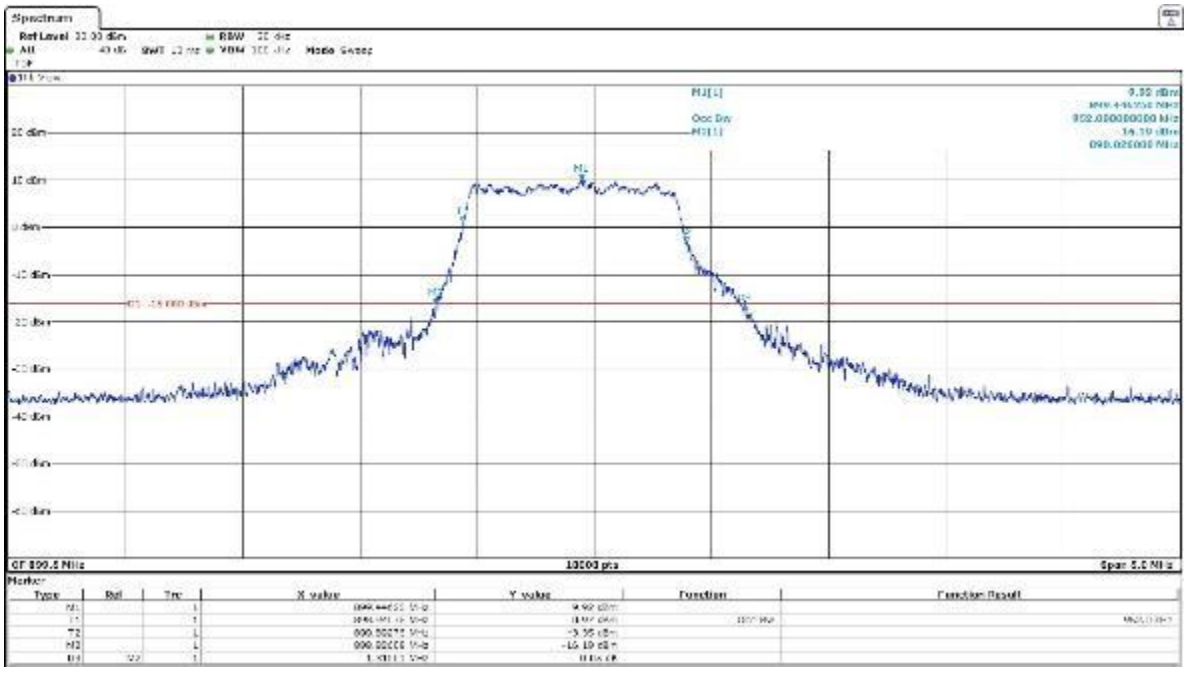
Lowest Channel



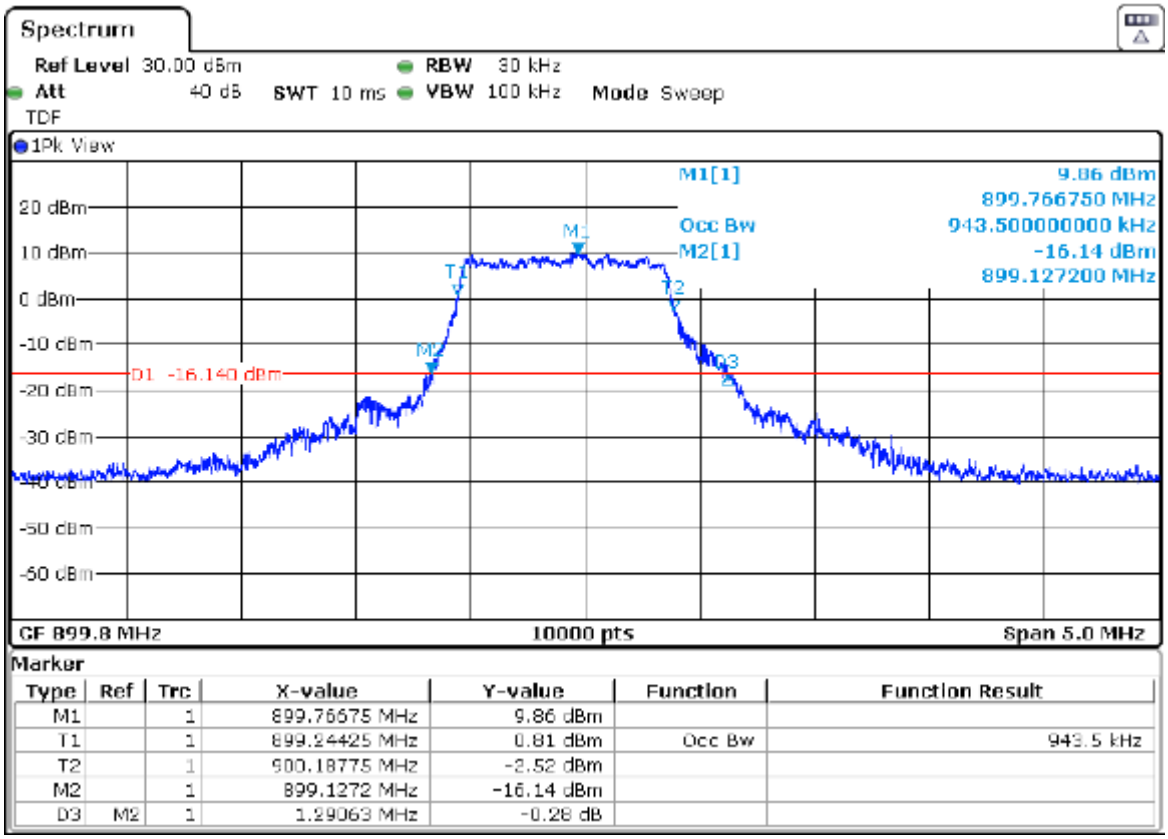
Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	898.30875 MHz	10.17 dBm		
T1		1	897.64525 MHz	0.70 dBm	Occ Bw	937.5 kHz
T2		1	898.58275 MHz	-1.54 dBm		
M2		1	897.5382 MHz	-15.89 dBm		
D3	M2	1	1.30413 MHz	-0.07 dB		

Middle Channel

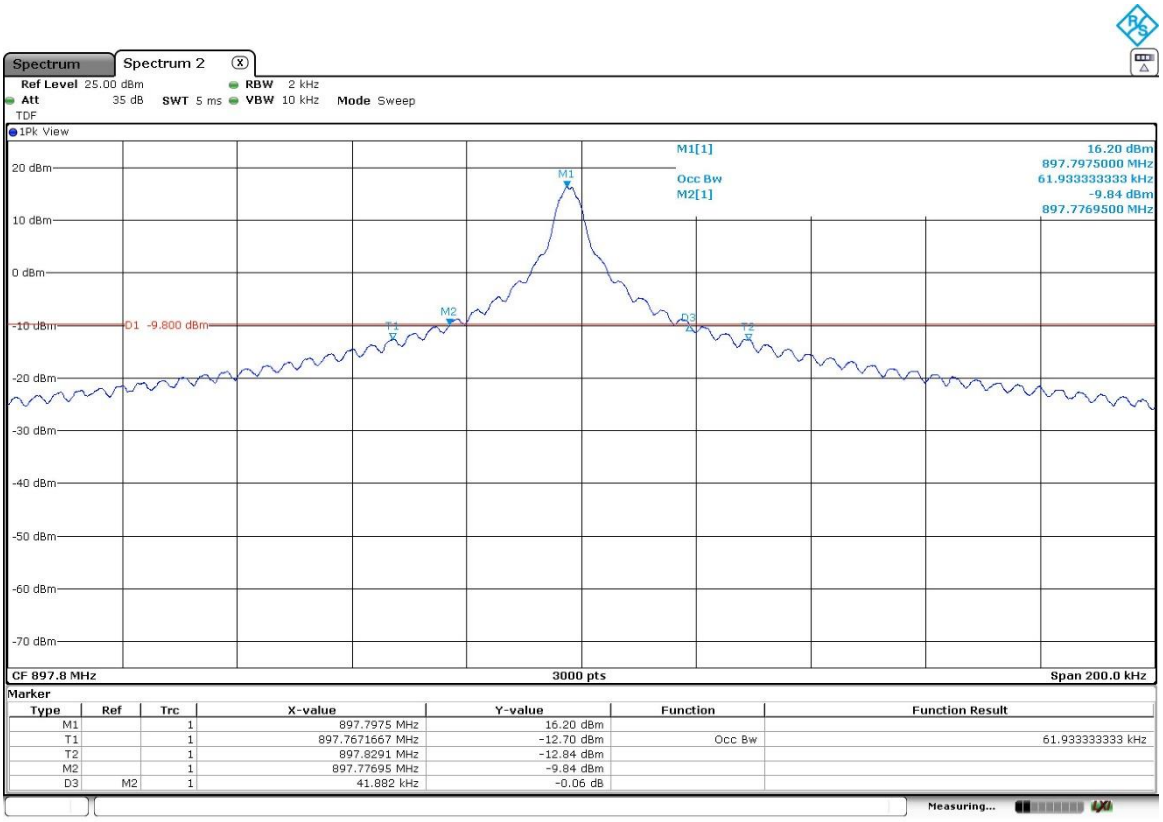


Highest Channel

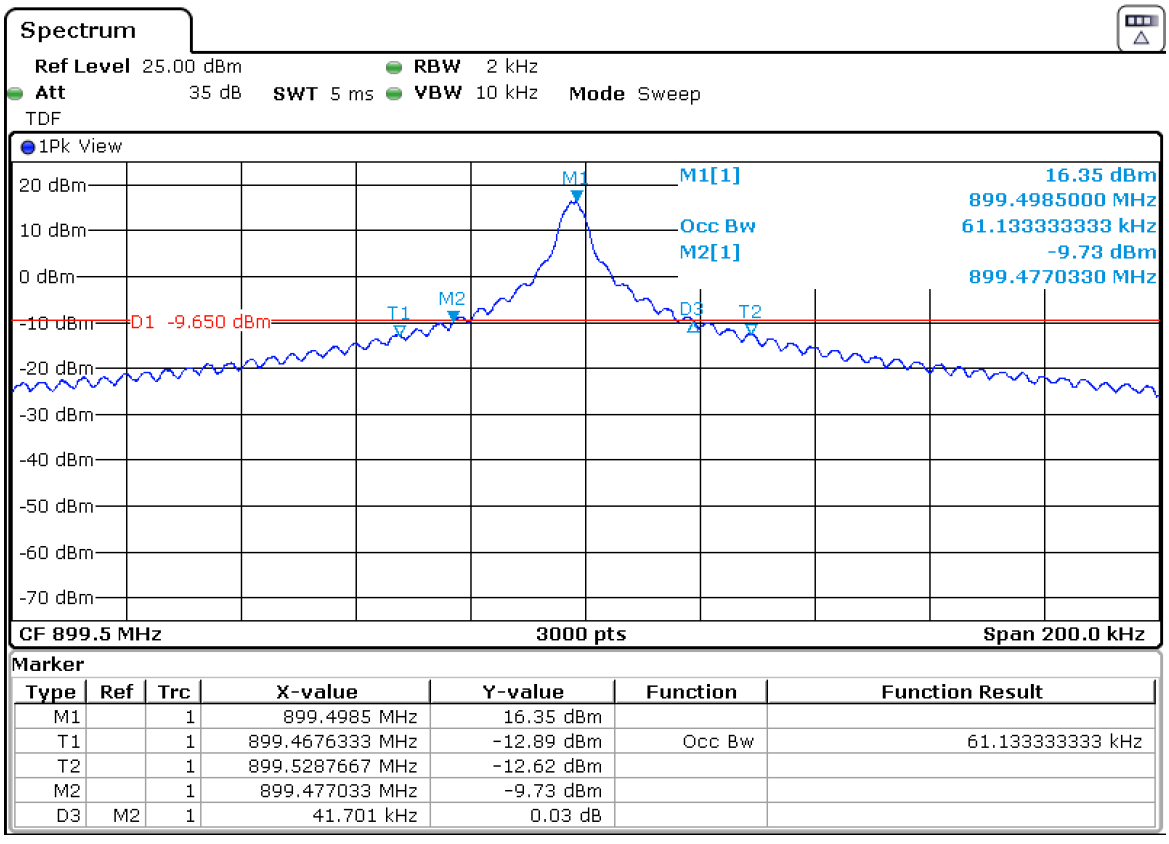


LTE NB-IoT pi/4-QPSK MODULATION (Band 8). 1 tone of 3.75kHz, Offset= 0

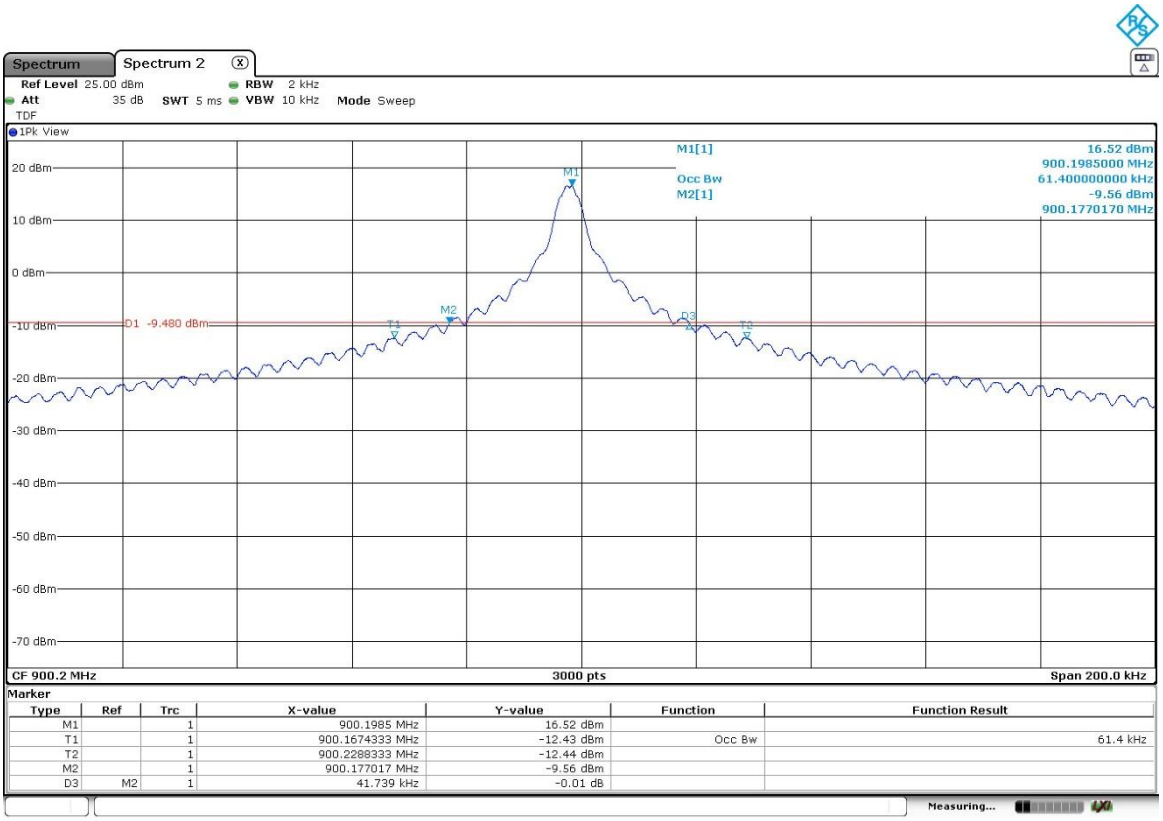
Lowest Channel



Middle Channel

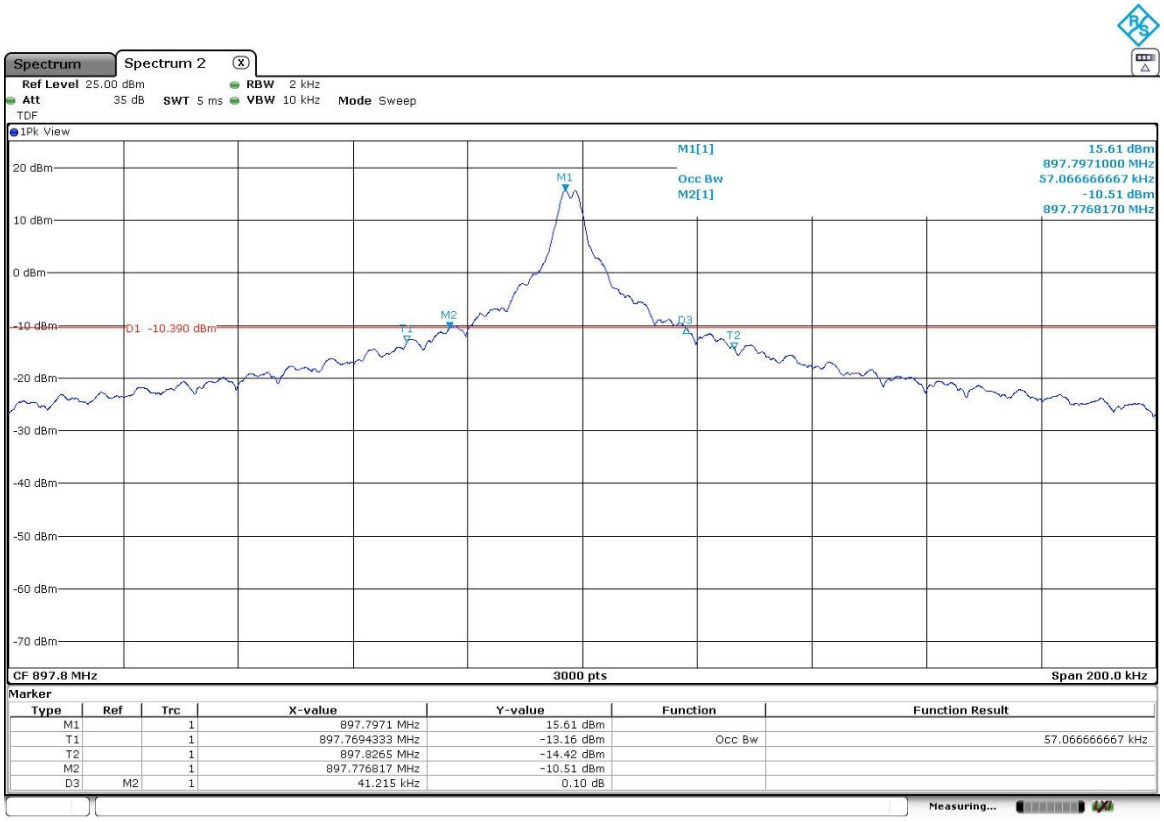


Highest Channel

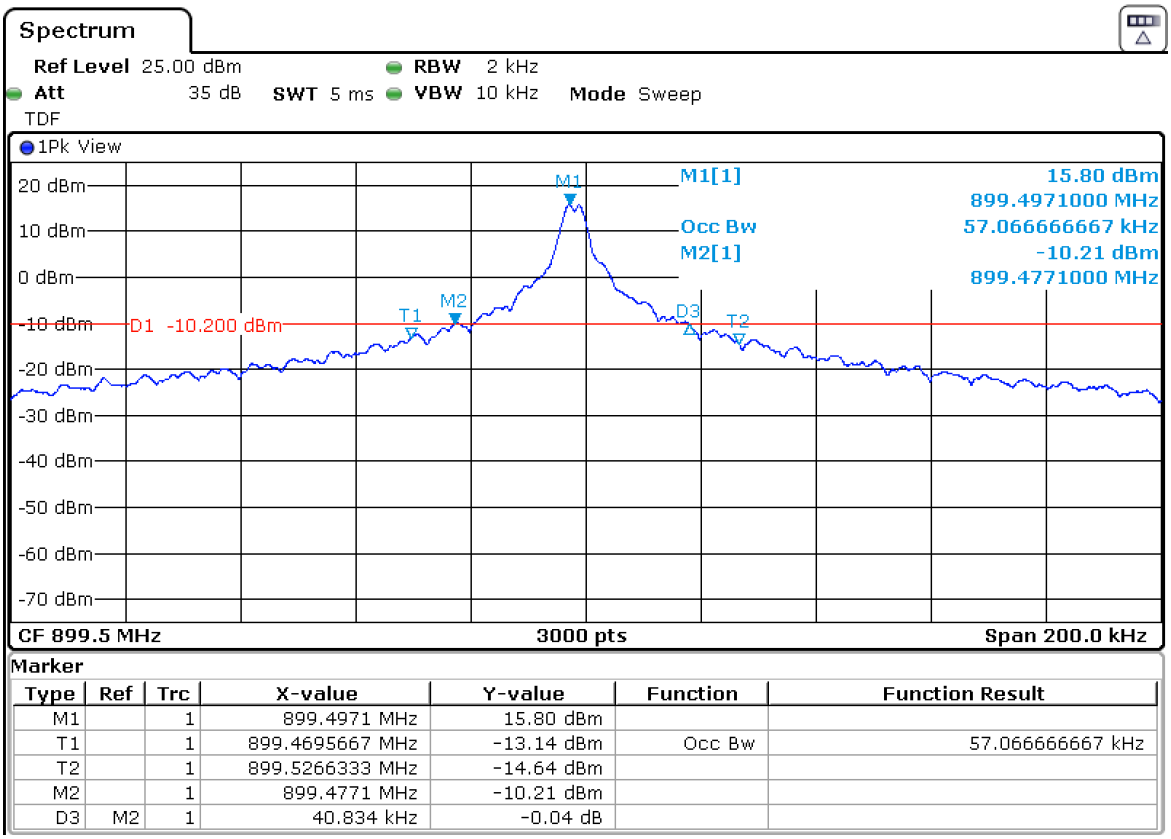


LTE NB-IoT pi/2-BPSK MODULATION (Band 8). 1 tone of 3.75kHz, Offset= 0

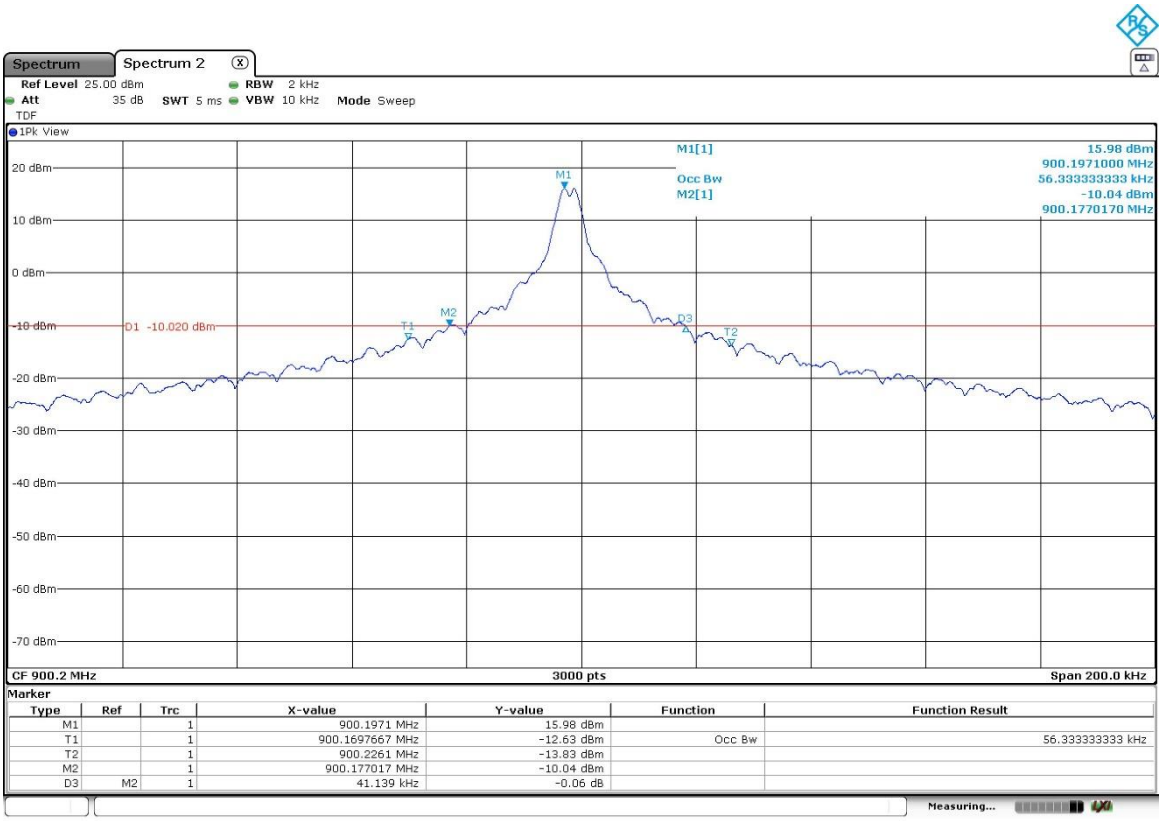
Lowest Channel



Middle Channel

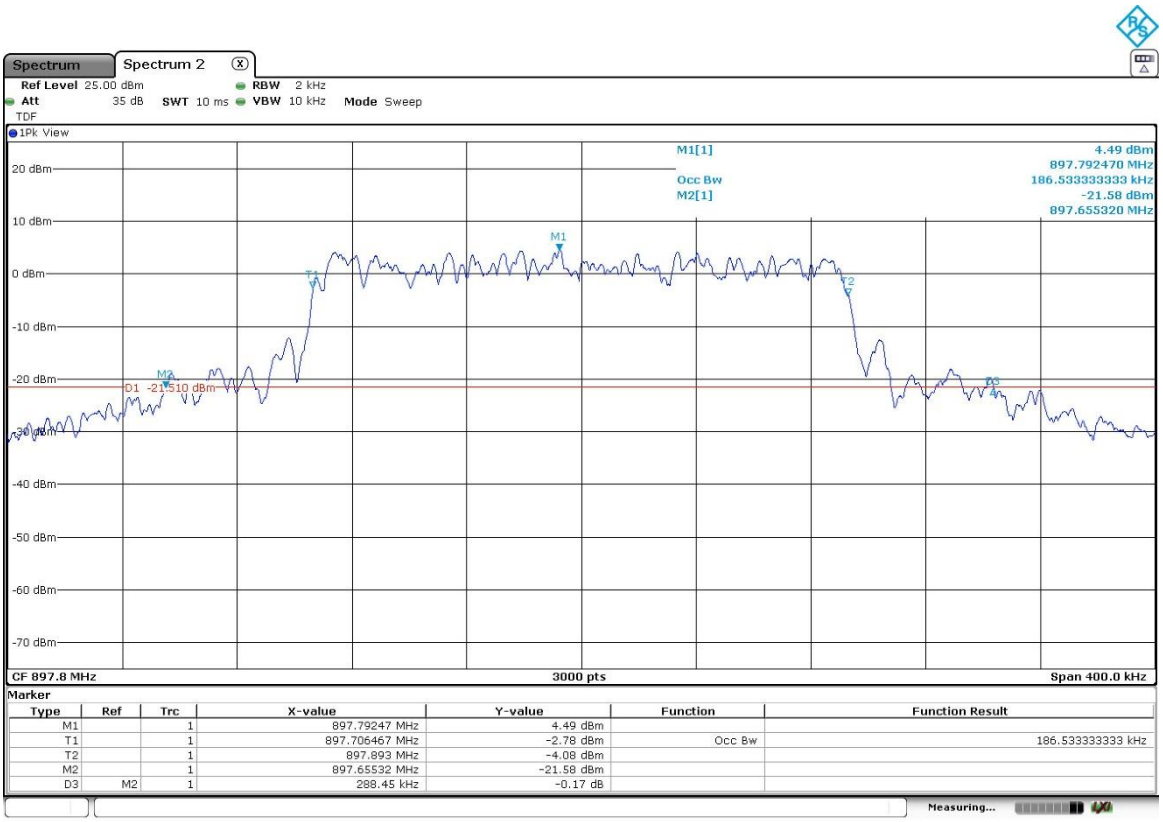


Highest Channel

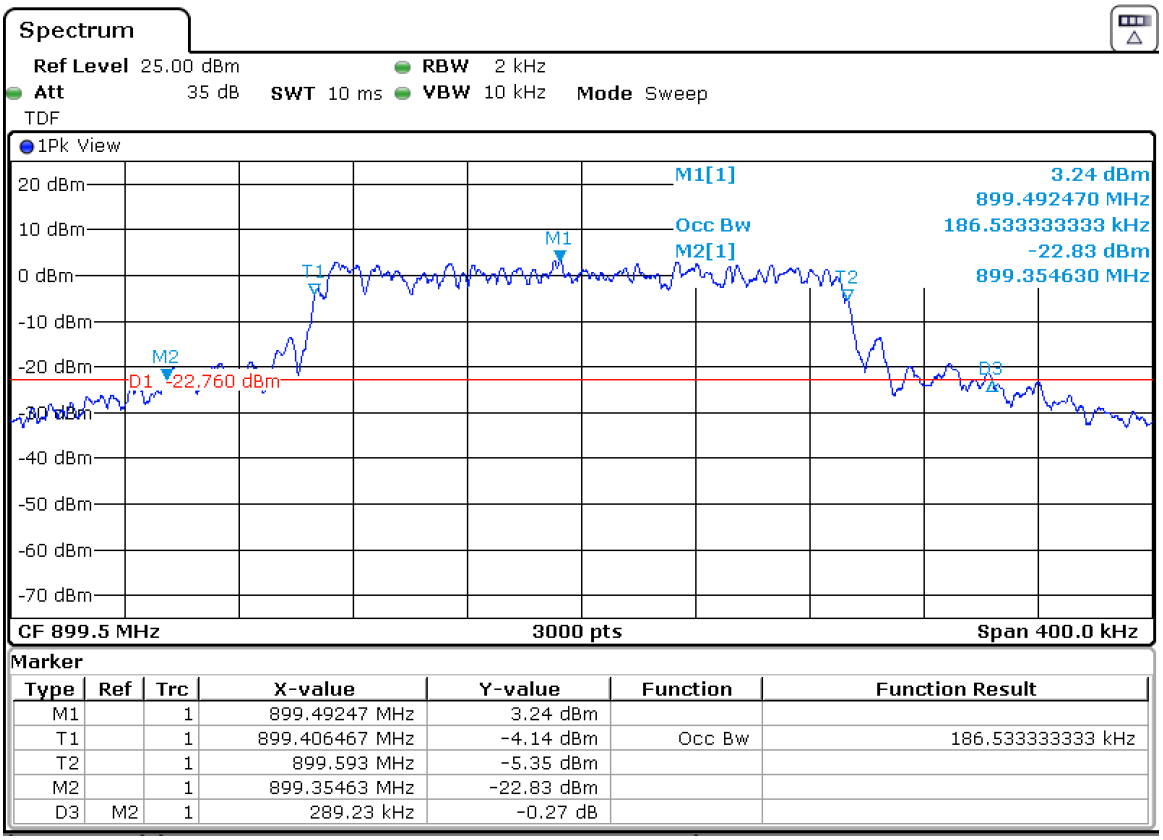


LTE NB-IoT pi/4-QPSK MODULATION (Band 8). 12 tones of 15kHz, Offset= 0

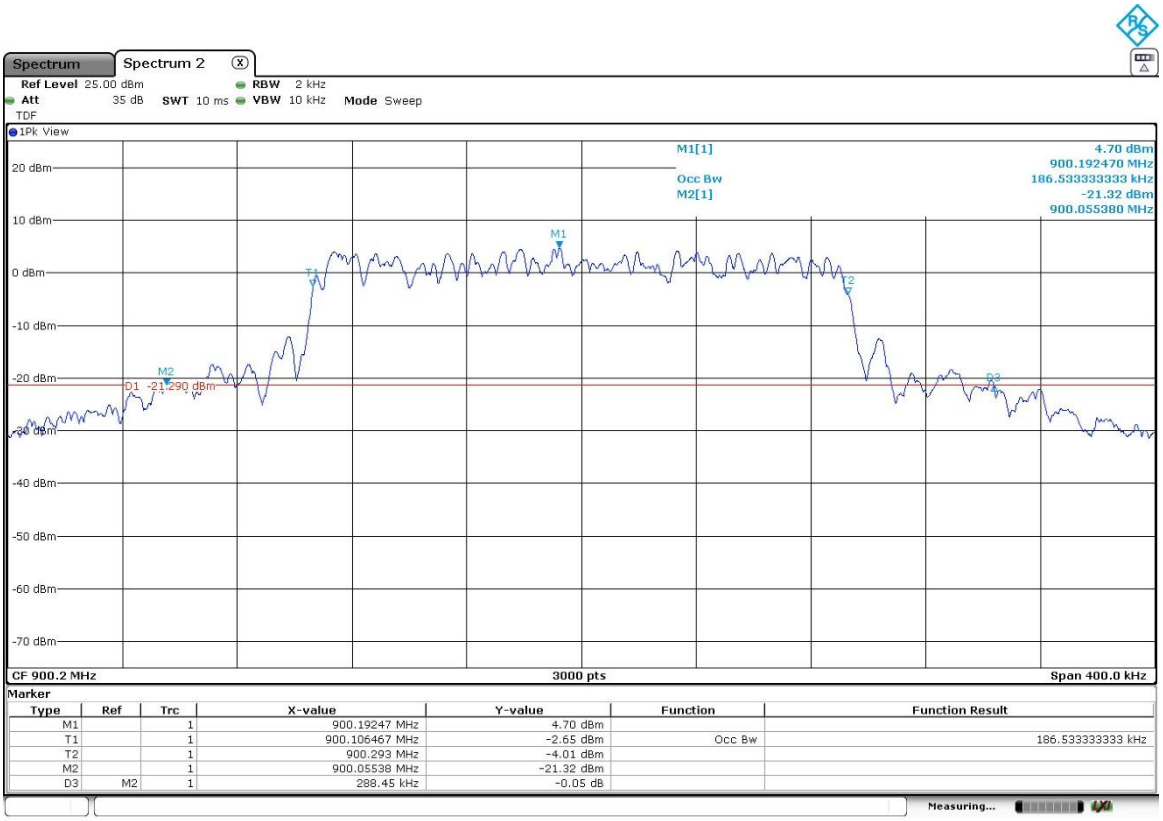
Lowest Channel



Middle Channel

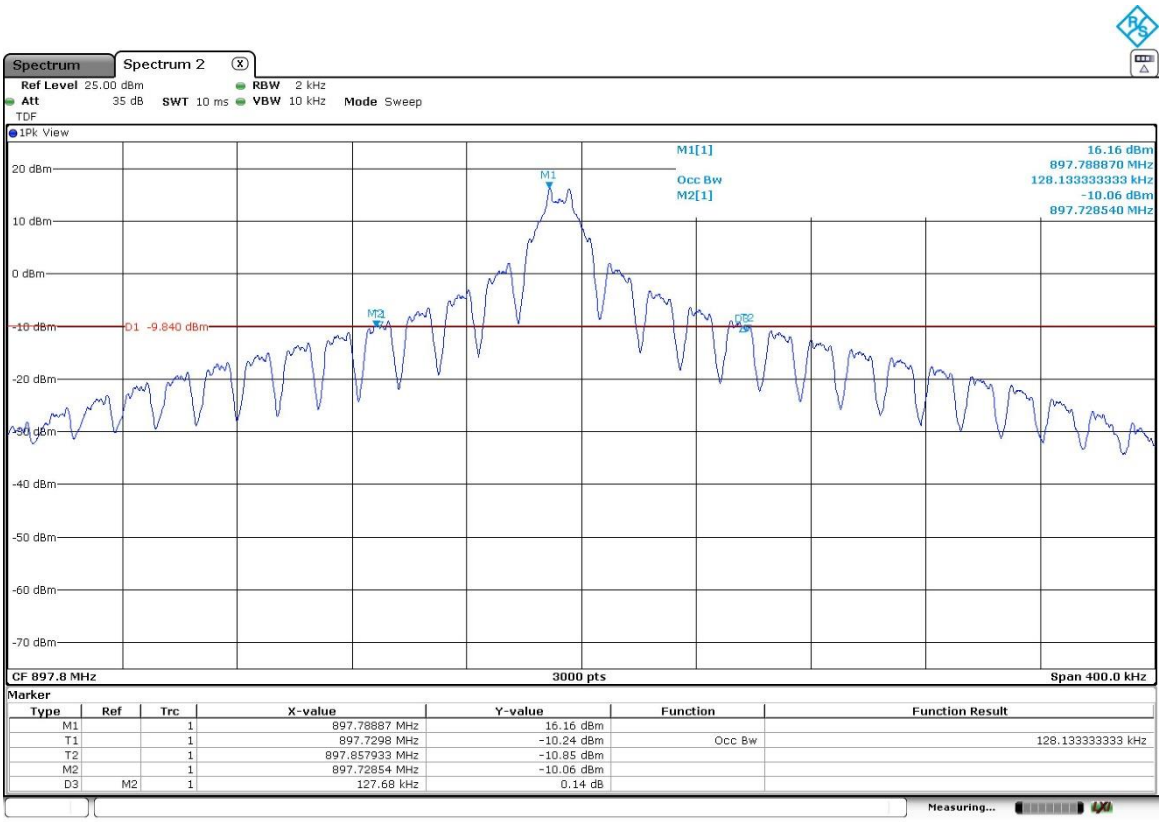


Highest Channel

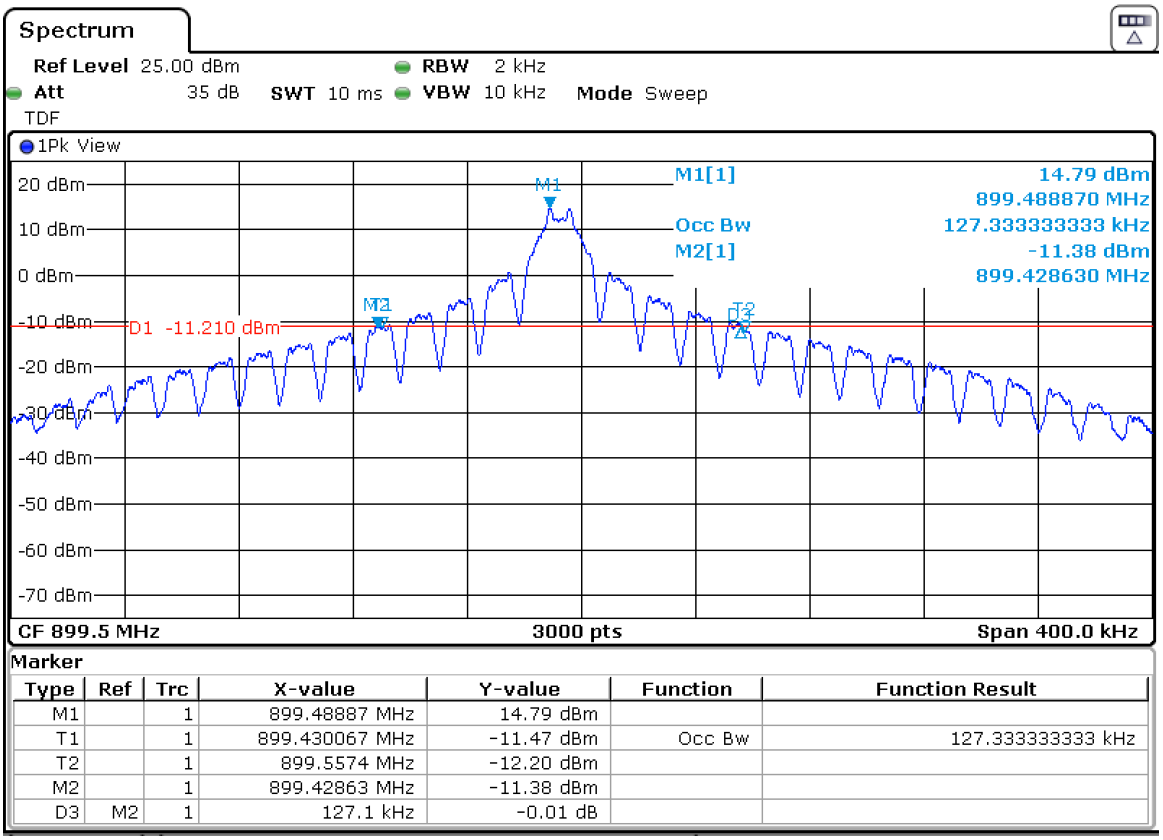


LTE NB-IoT pi/2-BPSK MODULATION (Band 8). 1 tone of 15kHz, Offset= 11

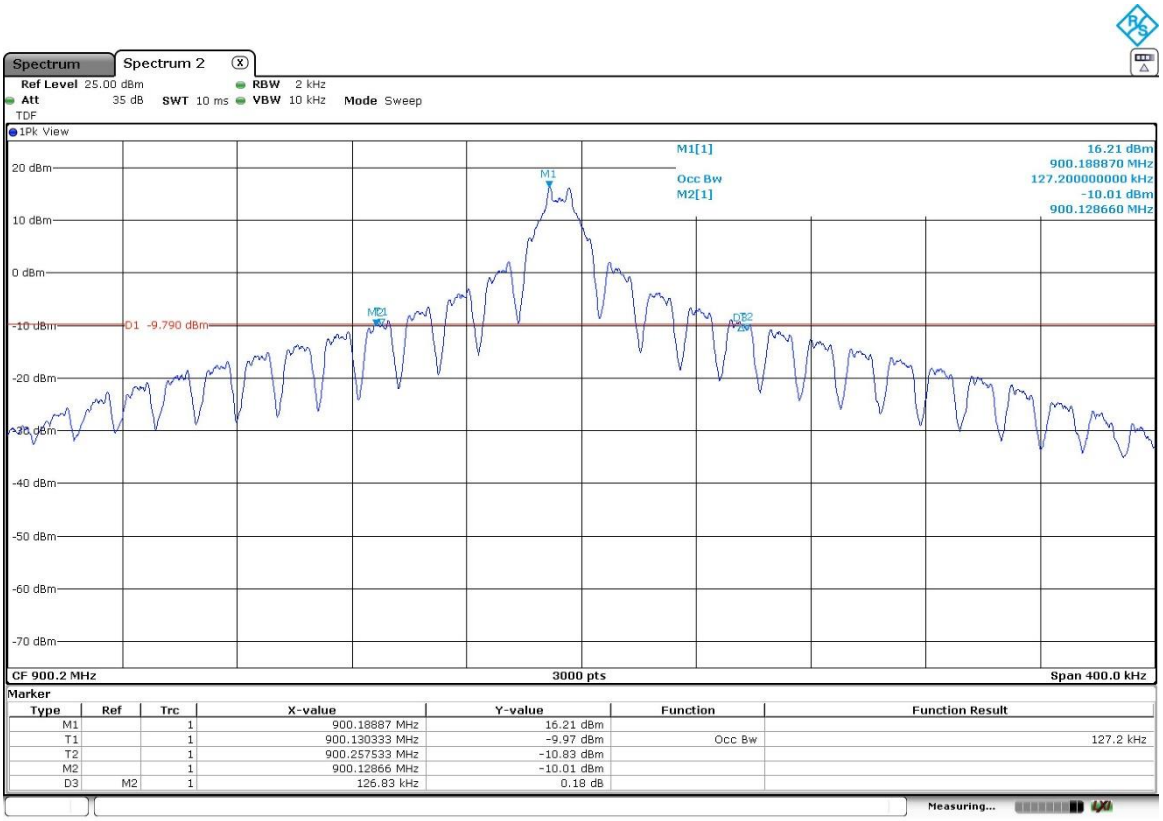
Lowest Channel



Middle Channel



Highest Channel



Spurious emissions at antenna terminals

SPECIFICATION

LTE Cat M1 Band 8. LTE NB-IoT Band 8. FCC Subpart P §27.1509 (a):

FCC §27.1509 (a):

(a) The power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) in watts by at least the following amounts:

For 900 MHz broadband operations in 897.5-900.5 MHz band by at least 43 + 10 log (P) dB.

METHOD

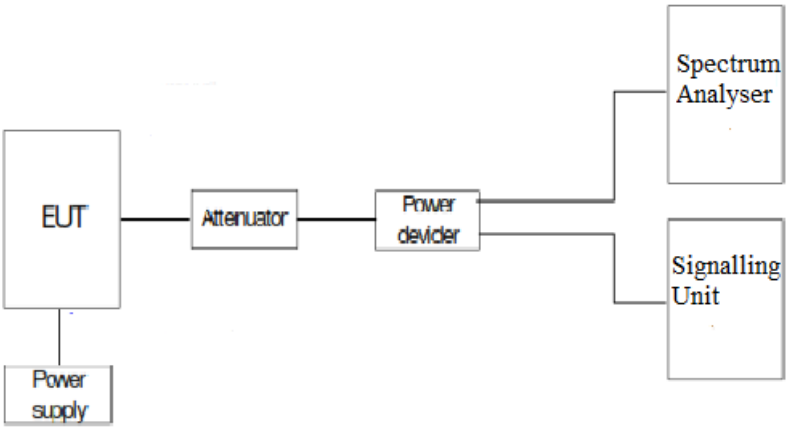
The EUT RF output connector was connected to a spectrum analyser and to the Universal Radio Communication tester R&S CMW500 (selecting maximum transmission power of the EUT and different modes of modulation) using a 50 ohm attenuator and a power divider.

The spectrum was investigated from 9 kHz to 10 GHz for LTE Band 8.

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

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

TEST SETUP



RESULTS (see plots in next pages)

LTE Cat. M1 Band 8

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

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

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

LTE NB-IoT Band 8. 1 tone of 3.75kHz

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

2. CHANNEL: MIDDLE

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

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

LTE NB-IoT Band 8. 1 tone of 15kHz

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

2. CHANNEL: MIDDLE

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

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

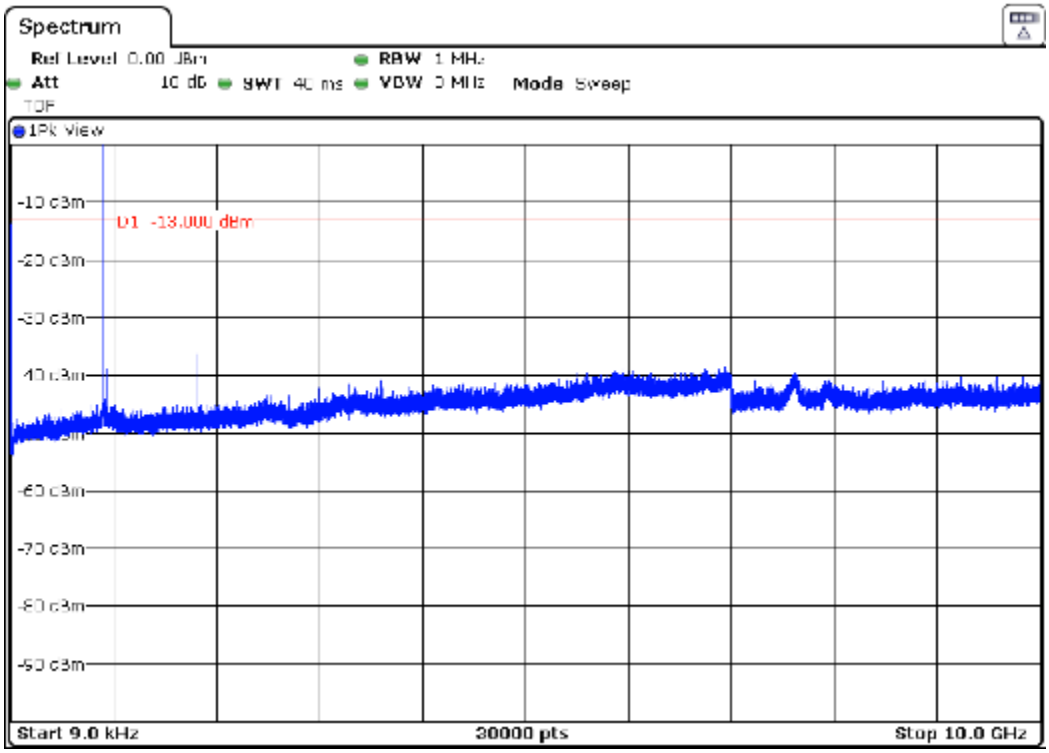
Measurement uncertainty = <±2.76 dB.

Verdict: PASS

LTE Cat. M1 Band 8

1. CHANNEL: LOWEST

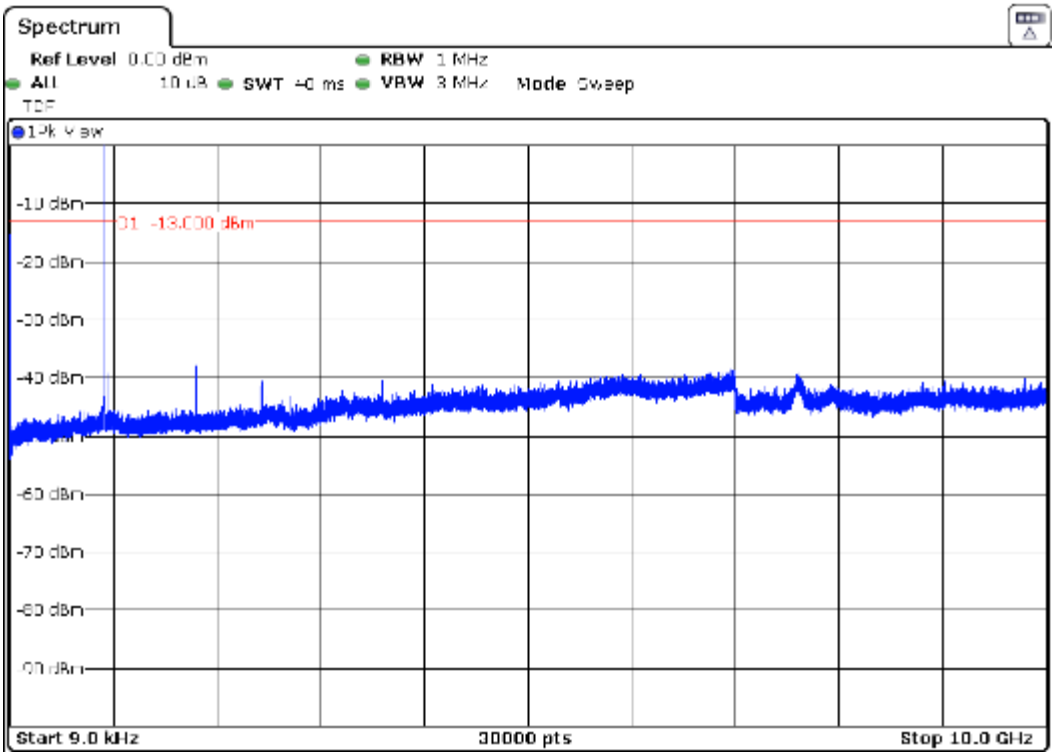
Frequency Range 9 kHz – 10 GHz



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

2. CHANNEL: MIDDLE

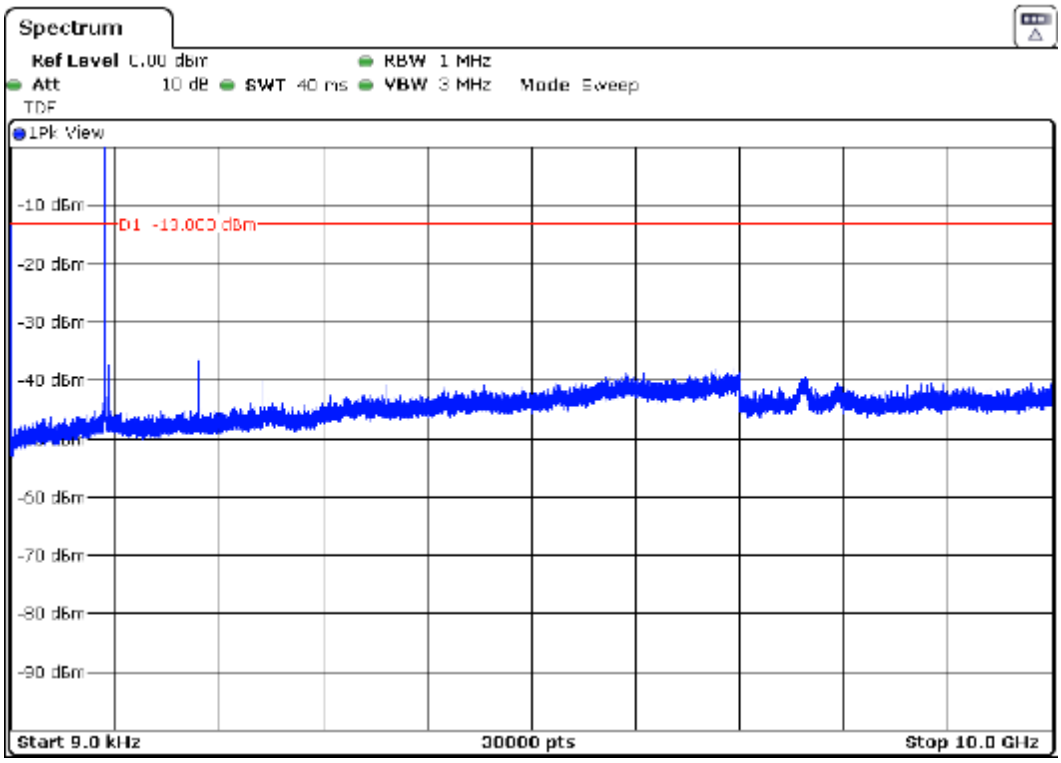
Frequency Range 9 kHz – 10 GHz



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

3. CHANNEL: HIGHEST

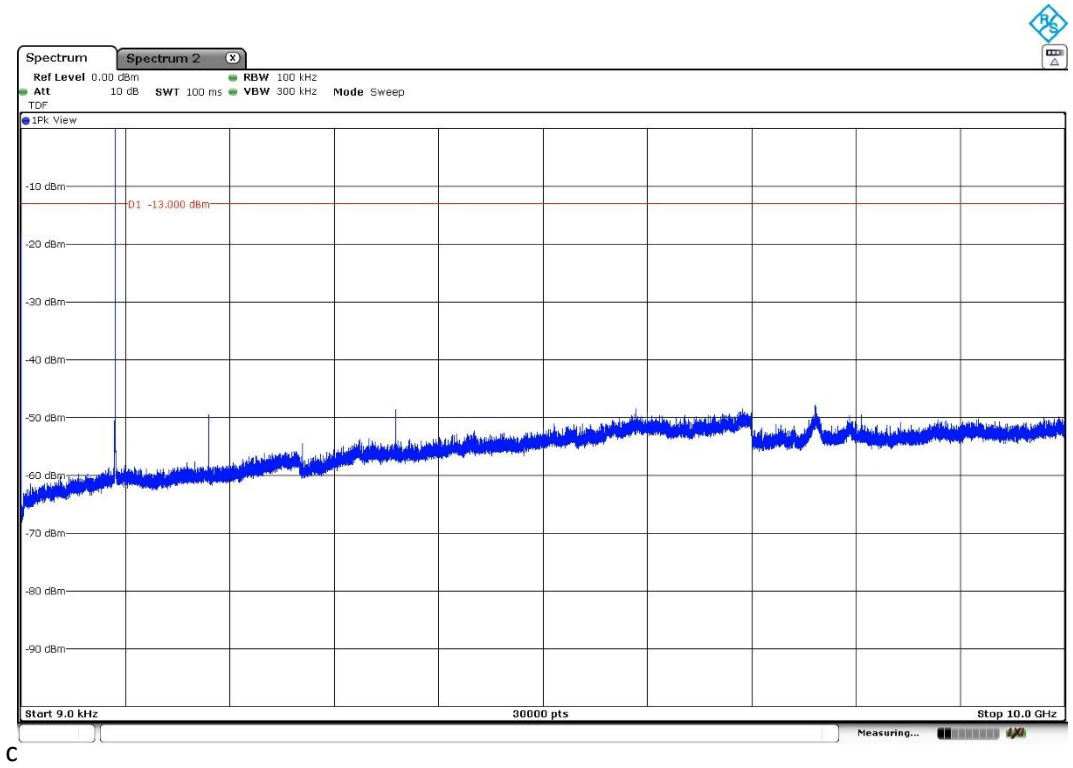
Frequency Range 9 kHz – 10 GHz



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

LTE NB-IoT Band 8. PI/2 – BPSK. 1 tone of 3.75kHz

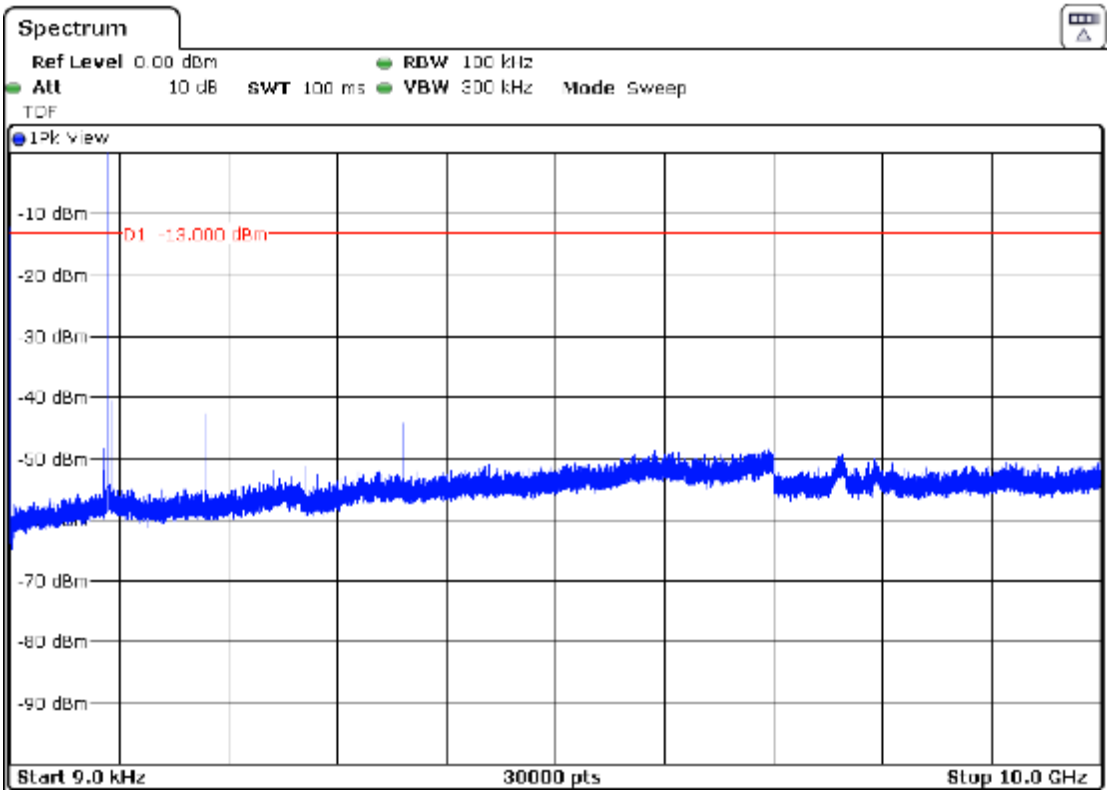
1. CHANNEL: LOWEST



c

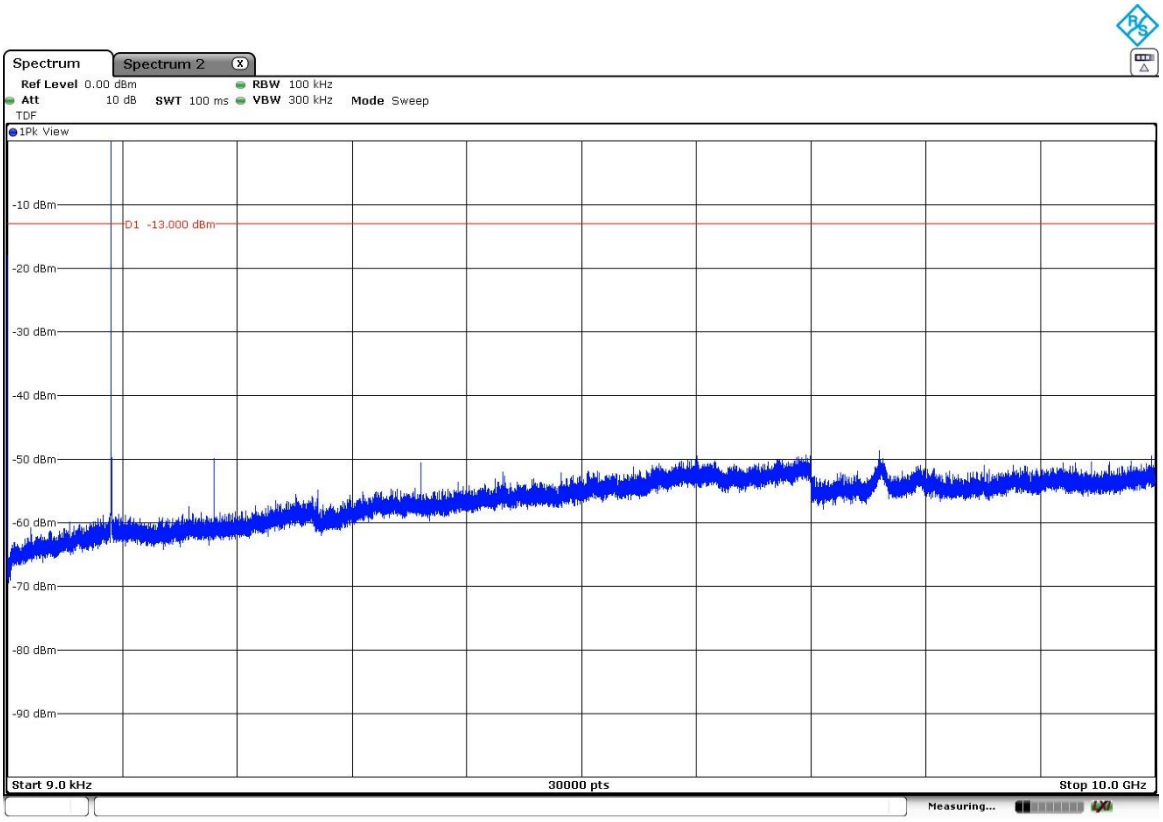
Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE



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

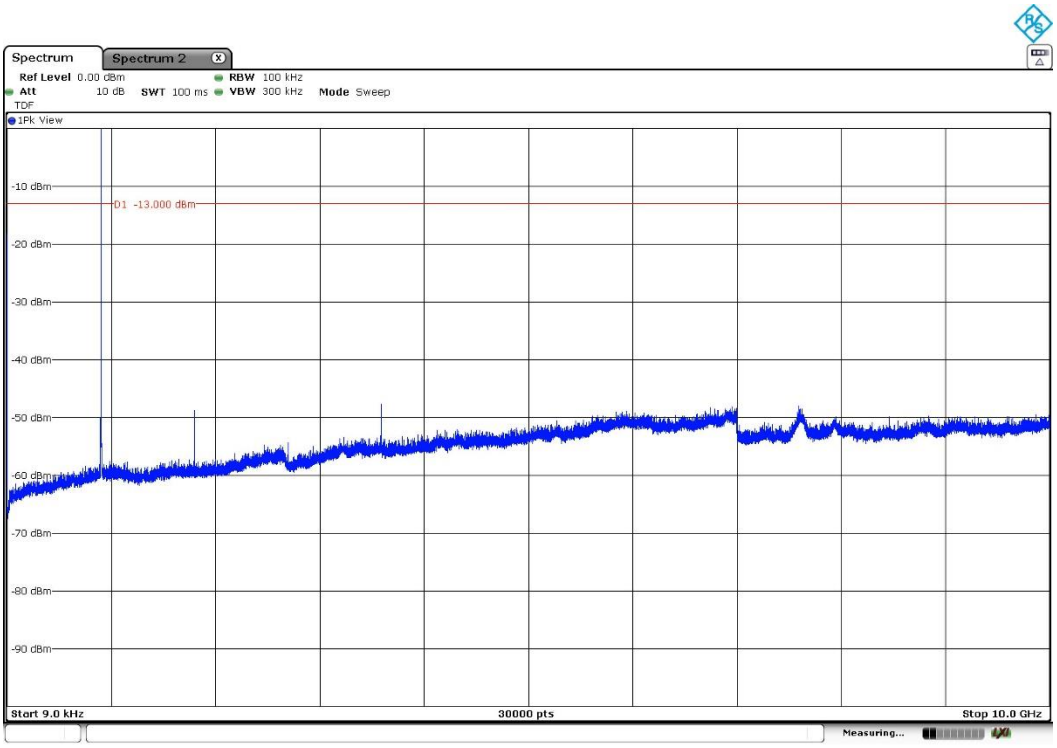
3. CHANNEL: HIGHEST



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

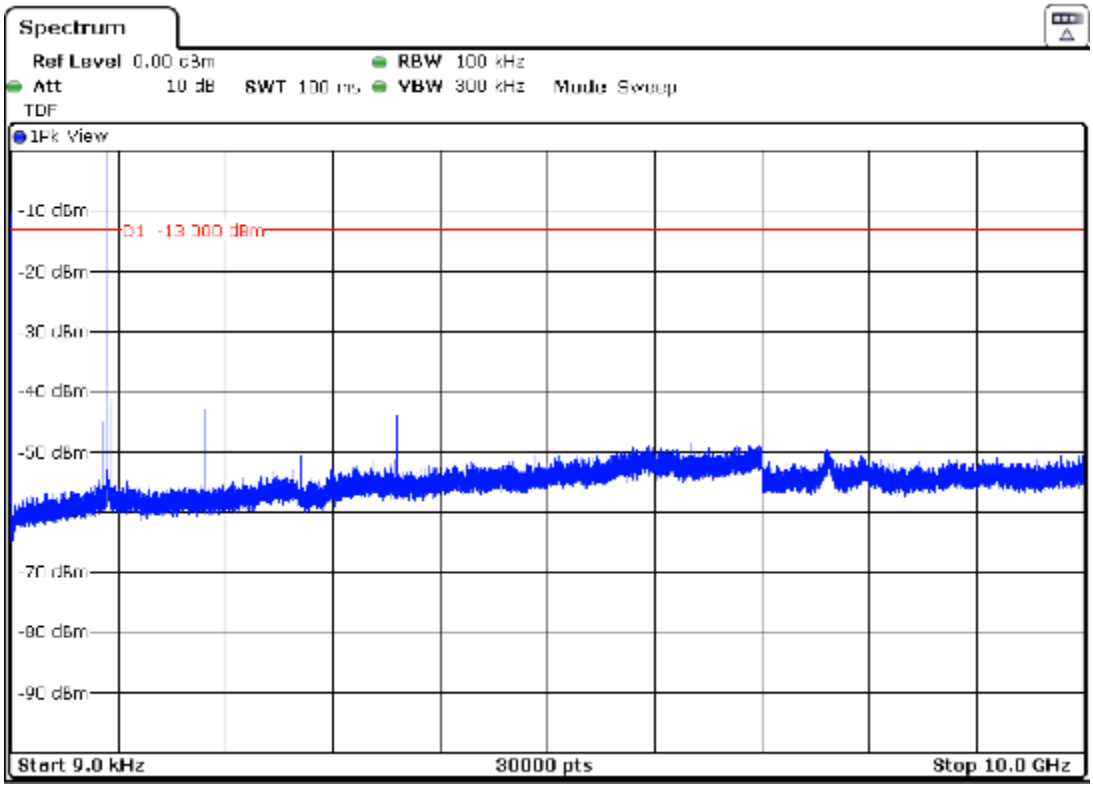
LTE NB-IoT Band 8. PI/4 – QPSK. 1 tone of 3.75 kHz

1. CHANNEL: LOWEST



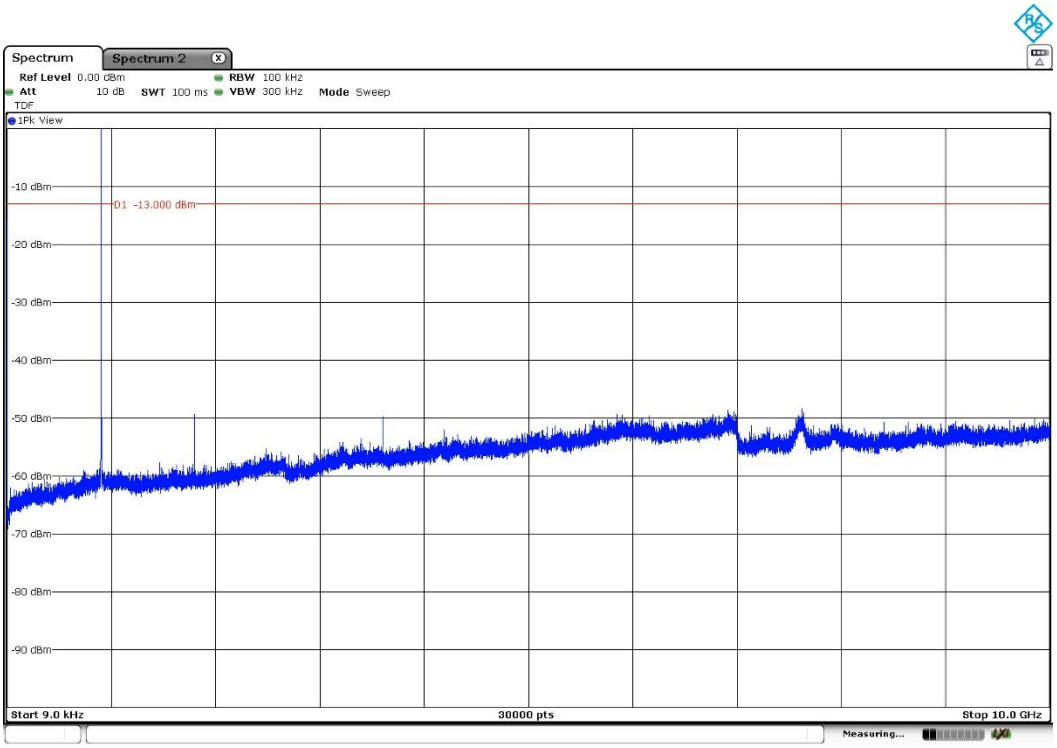
Note: The peak above the limit is the carrier frequency.

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

LTE Cat M1 Band 8. LTE NB-IoT Band 8. FCC Subpart P §27.1509 (a):

FCC §27.1509 (a):

(a) The power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) in watts by at least the following amounts:

For 900 MHz broadband operations in 897.5-900.5 MHz band by at least 43 + 10 log (P) dB.

METHOD

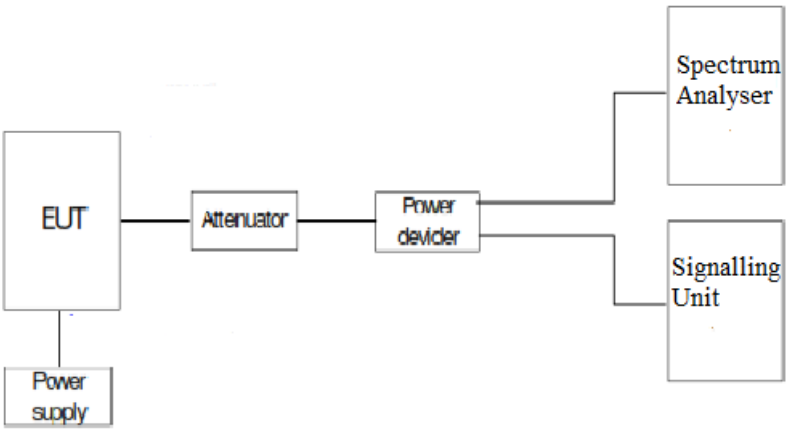
The EUT RF output connector was connected to a spectrum analyser and to the Universal Radio Communication tester R&S CMW500 (selecting maximum transmission power of the EUT and different modes of modulation) using a 50 ohm attenuator and a power splitter.

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

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

For LTE Band 8, as indicated in FCC part 27.1509 (c), in the 100 kHz bands immediately outside and adjacent to the licensee's band, a resolution bandwidth of 30 kHz may be employed.

TEST SETUP



RESULTS

LTE Cat. M1 Band 8

Preliminary measurements determined the narrow band = 0 and nominal bandwidth of 1.4 MHz as the worst case. The results in the next tables shows the results for this configuration.

(Channels in Band 8):	RB=1. Offset=0. Narrow band = 0 BW=1.4 MHz	RB= All. Offset=0. Narrow band = 0 BW=1.4 MHz
Maximum measured level at lowest Block Edge at antenna port (dBm)	-26.29	-36.14

(Channels in Band 8):	RB= 1. Offset=Max. Narrow band = 0 BW=1.4 MHz	RB= All. Offset=0. Narrow band = 0 BW=1.4 MHz
Maximum measured level at highest Block Edge at antenna port (dBm)	-33.24	-34.69

LTE NB-IoT Band 8

The results in the next tables shows the results for this configuration.

(Channels in Band 8):	1 tone of 3.75kHz Pi/2-BPSK Offset=0 MCS/TBS=0	1 tone of 15kHz Pi/2-BPSK Offset=0 MCS/TBS=0	12 tones of 15kHz Pi/4-QPSK Offset=0 MCS/TBS=5
Maximum measured level at lowest Block Edge at antenna port (dBm)	-23,86	-38,1	-27,67

(Channels in Band 8):	1 tone of 3.75kHz Pi/2-BPSK Offset=47 MCS/TBS=0	1 tone of 15kHz Pi/2-BPSK Offset=11 MCS/TBS=0	12 tones of 15kHz Pi/4-QPSK Offset=0 MCS/TBS=5
Maximum measured level at highest Block Edge at antenna port (dBm)	-26,96	-32,89	-27,44

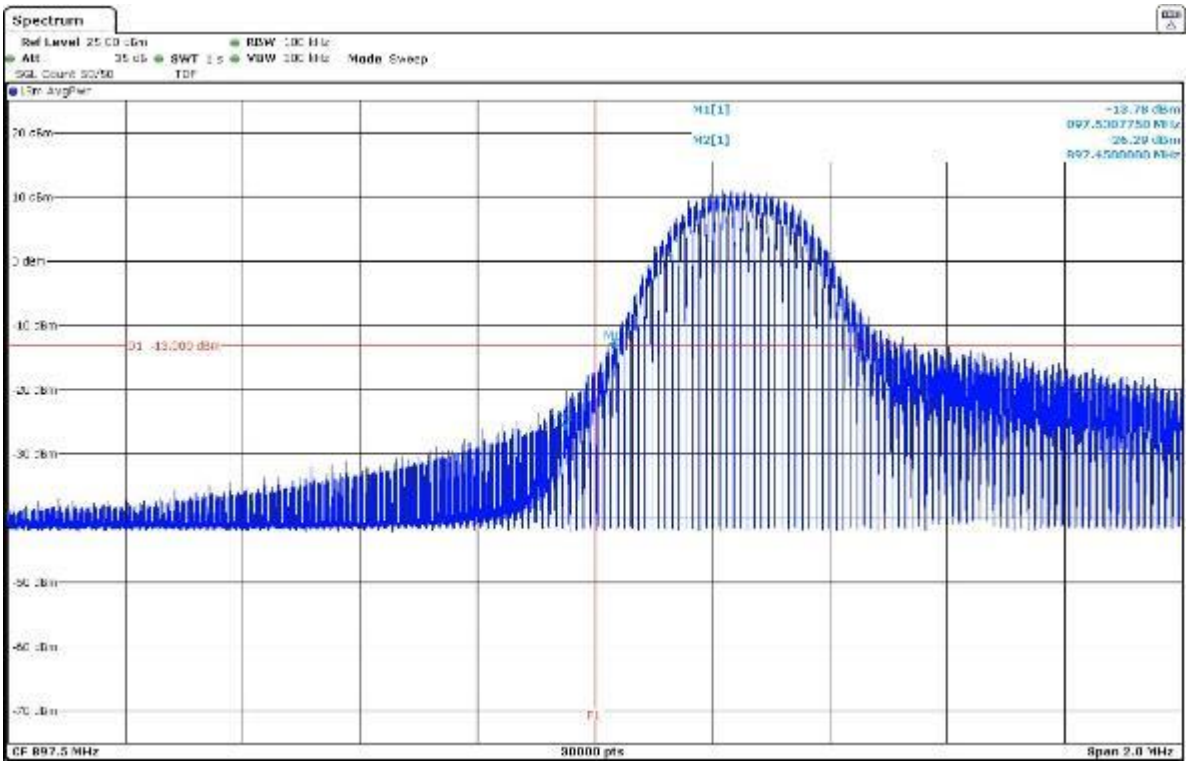
Measurement uncertainty = <±2.76 dB.

Verdict: Pass

LTE Cat. M1 Band 8

Narrow band = 0. RB = 1. Offset = 0. BW = 1.4 MHz

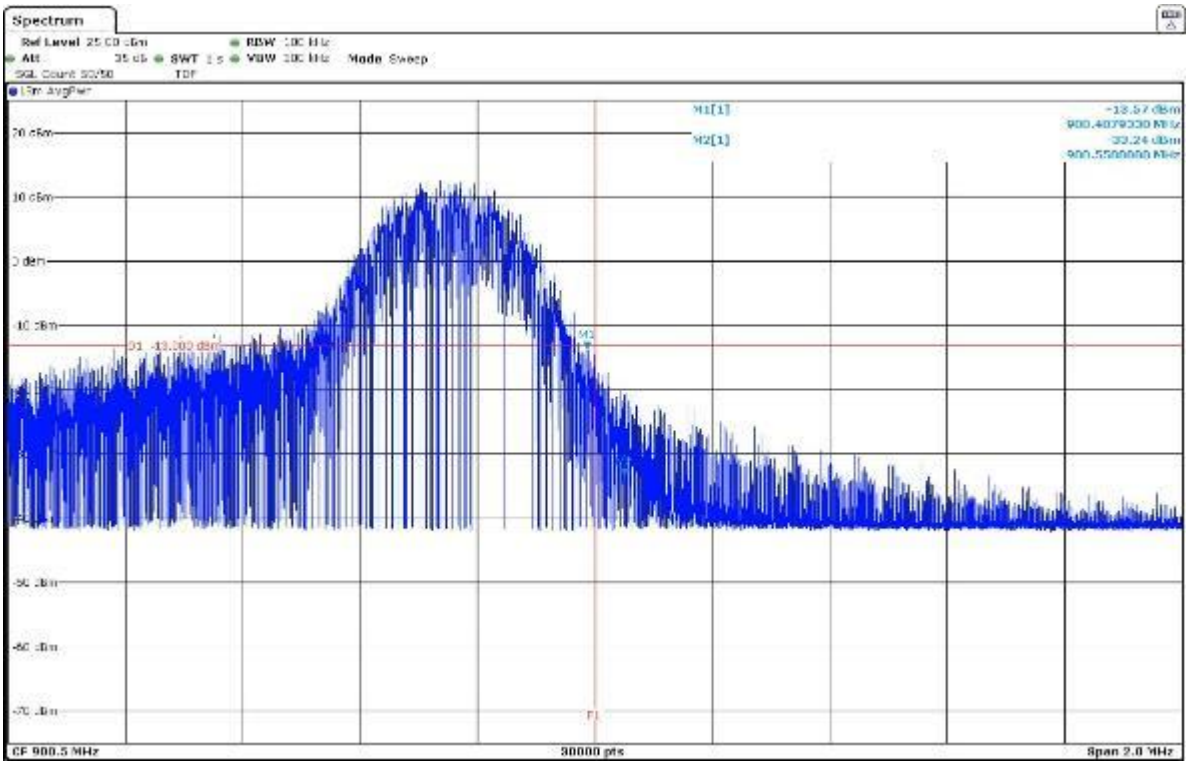
CHANNEL LOWEST



NOTE: The equipment transmits at the maximum output power

Narrow band = 0. RB = 1. Offset = Max. BW = 1.4 MHz

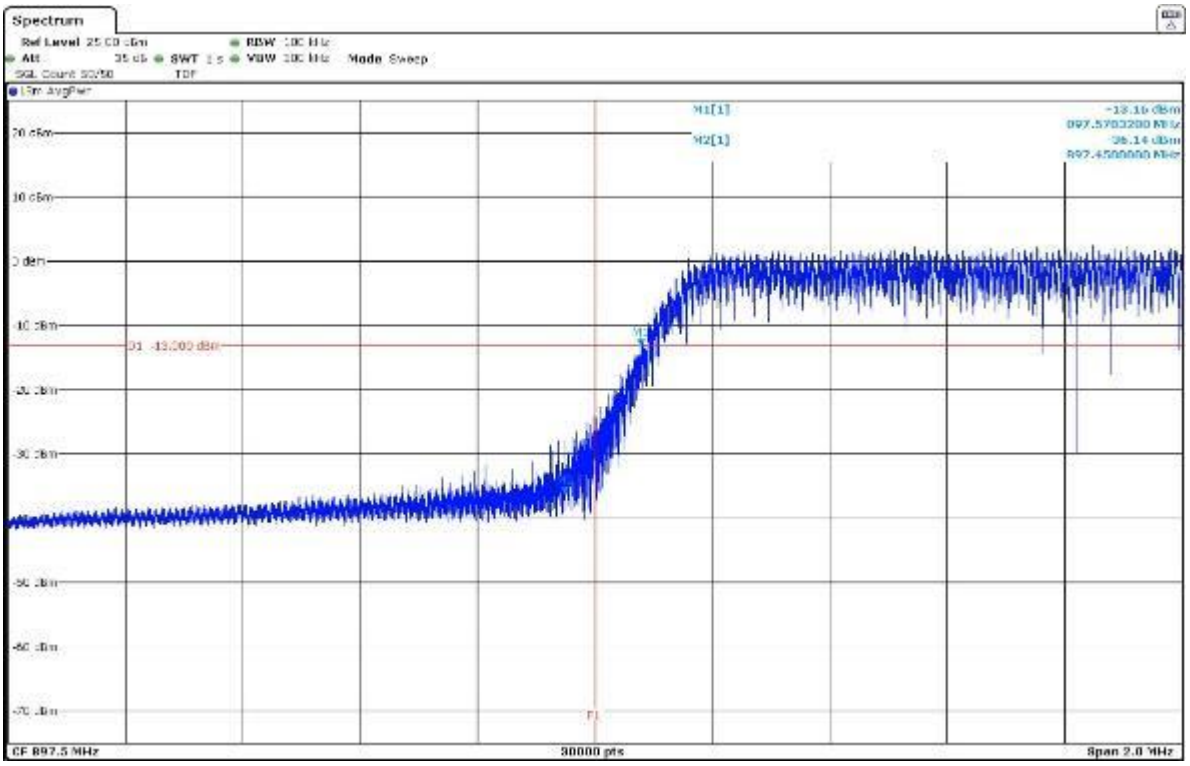
CHANNEL HIGHEST



NOTE: The equipment transmits at the maximum output power

Narrow band = 0. RB = All. Offset = 0. BW = 1.4 MHz

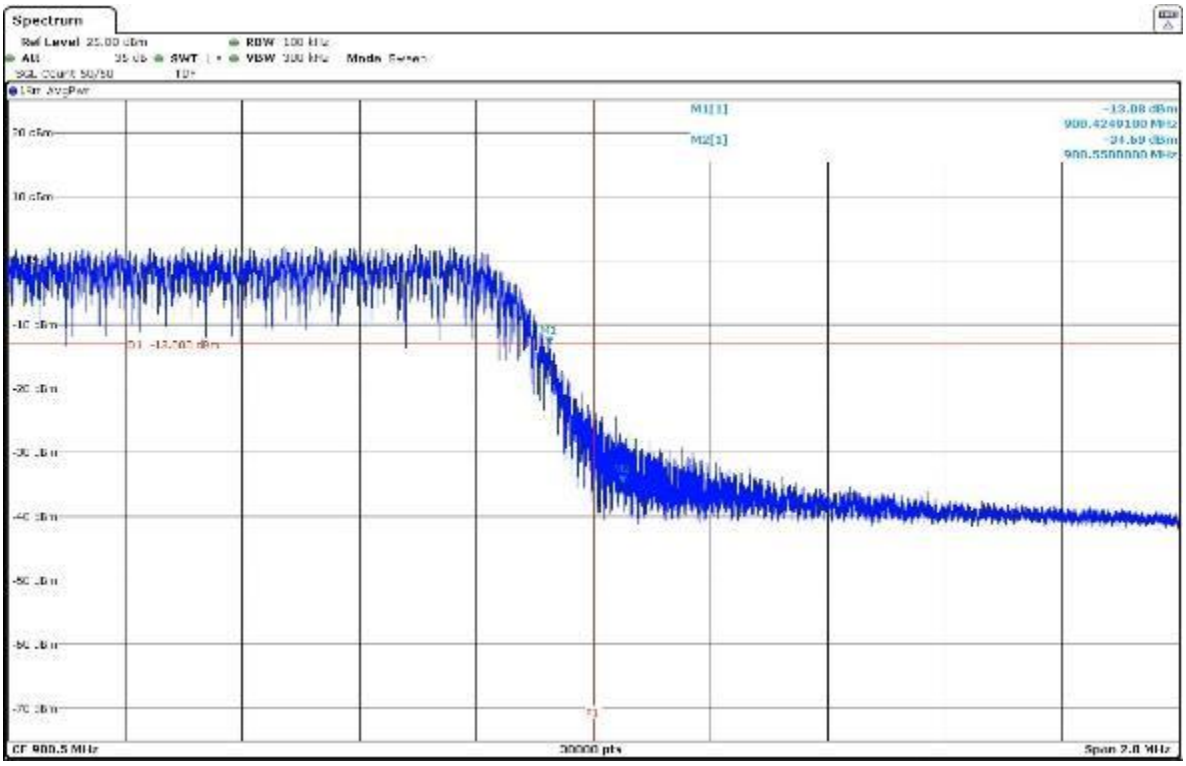
CHANNEL LOWEST



NOTE: The equipment transmits at the maximum output power

Narrow band = 0. RB = All. Offset = 0. BW = 1.4 MHz

CHANNEL HIGHEST



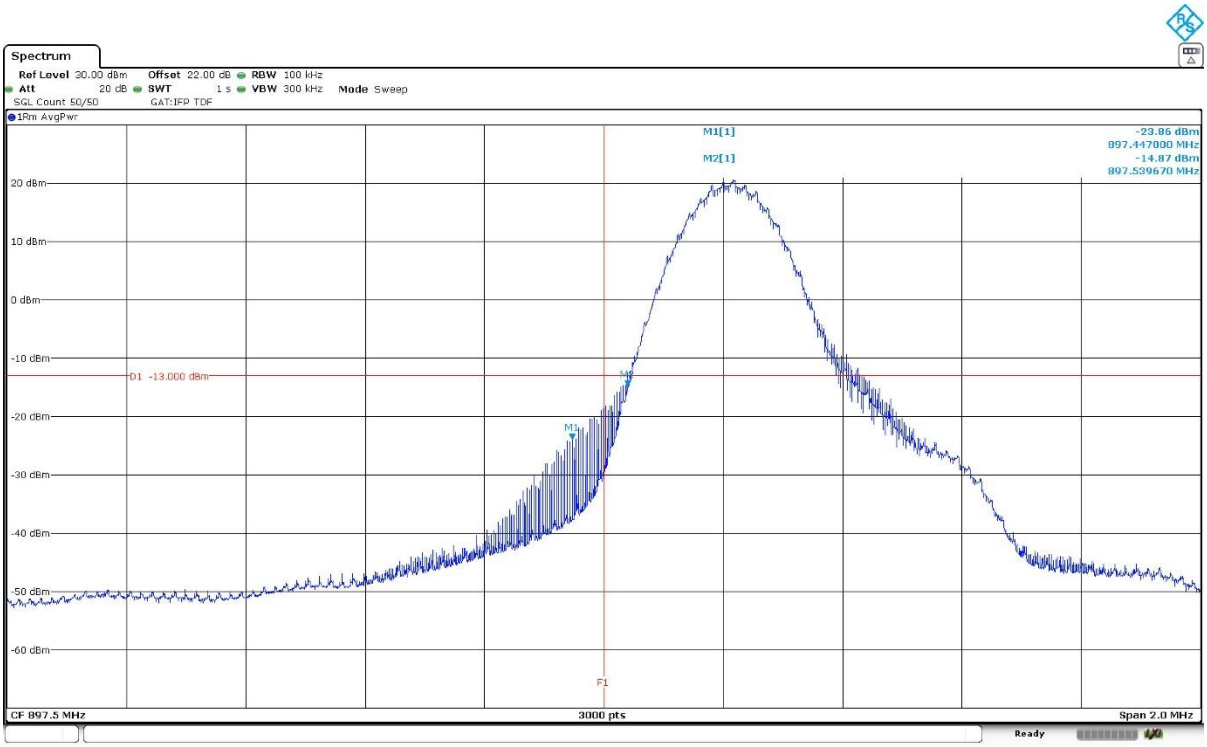
NOTE: The equipment transmits at the maximum output power

Verdict: Pass

LTE NB-IoT Band 8

1 tone of 3.75kHz, Pi/2-BPSK. Offset=0, MCS / TBS=0

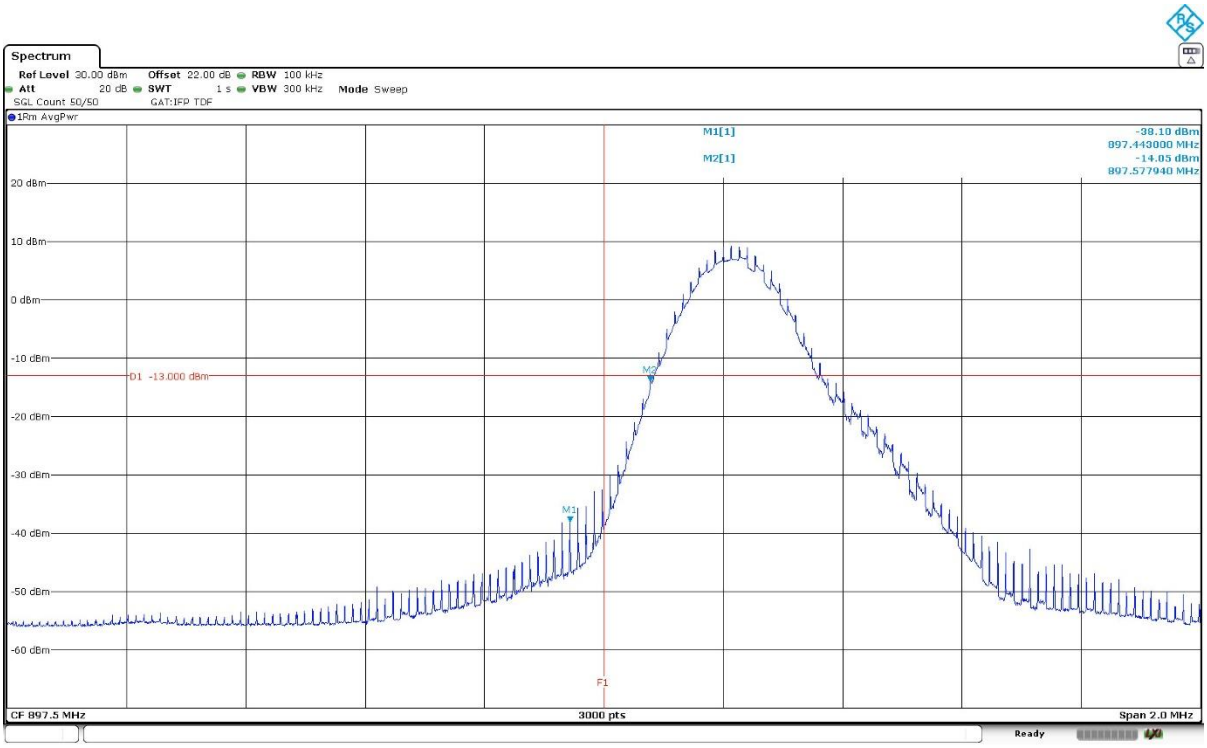
CHANNEL LOWEST



NOTE: The equipment transmits at the maximum output power

1 tone of 15kHz, Pi/2-BPSK. Offset=0, MCS / TBS=0

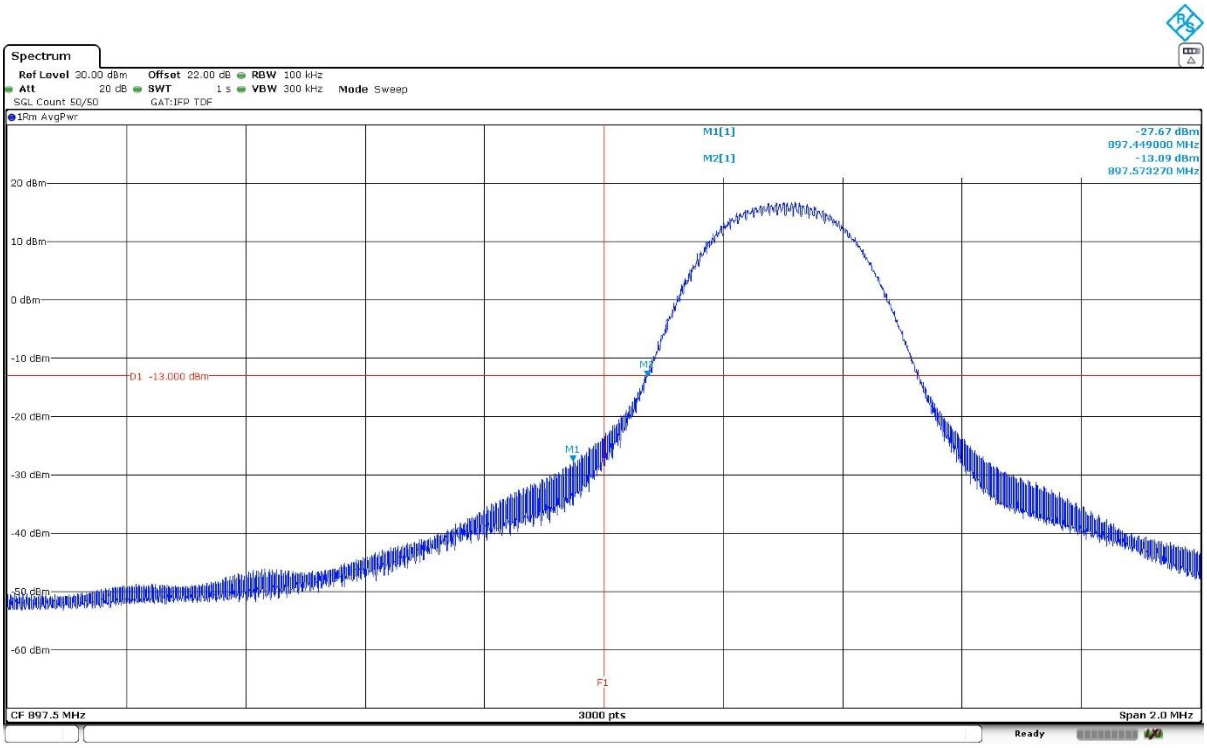
CHANNEL LOWEST



NOTE: The equipment transmits at the maximum output power

12 tones of 15kHz, Pi/2-BPSK. Offset=0, MCS / TBS=0

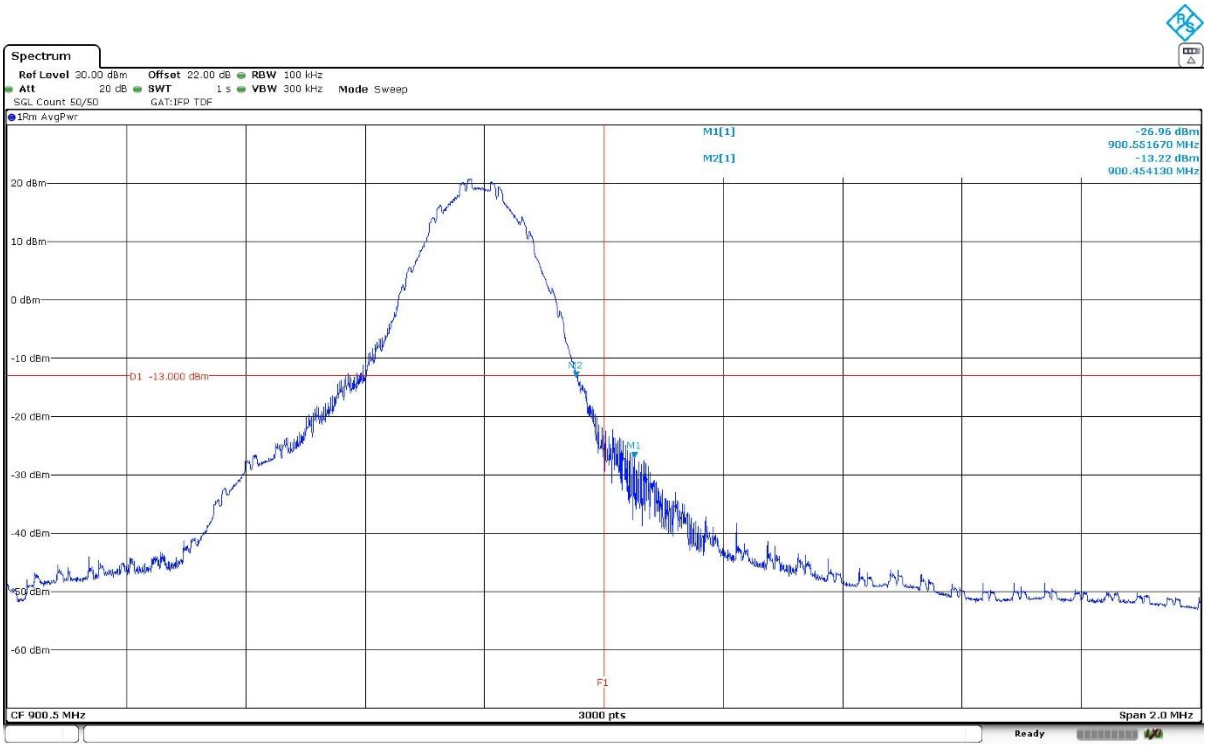
CHANNEL LOWEST



NOTE: The equipment transmits at the maximum output power

1 tone of 3.75kHz, Pi/2-BPSK. Offset=47, MCS / TBS=0

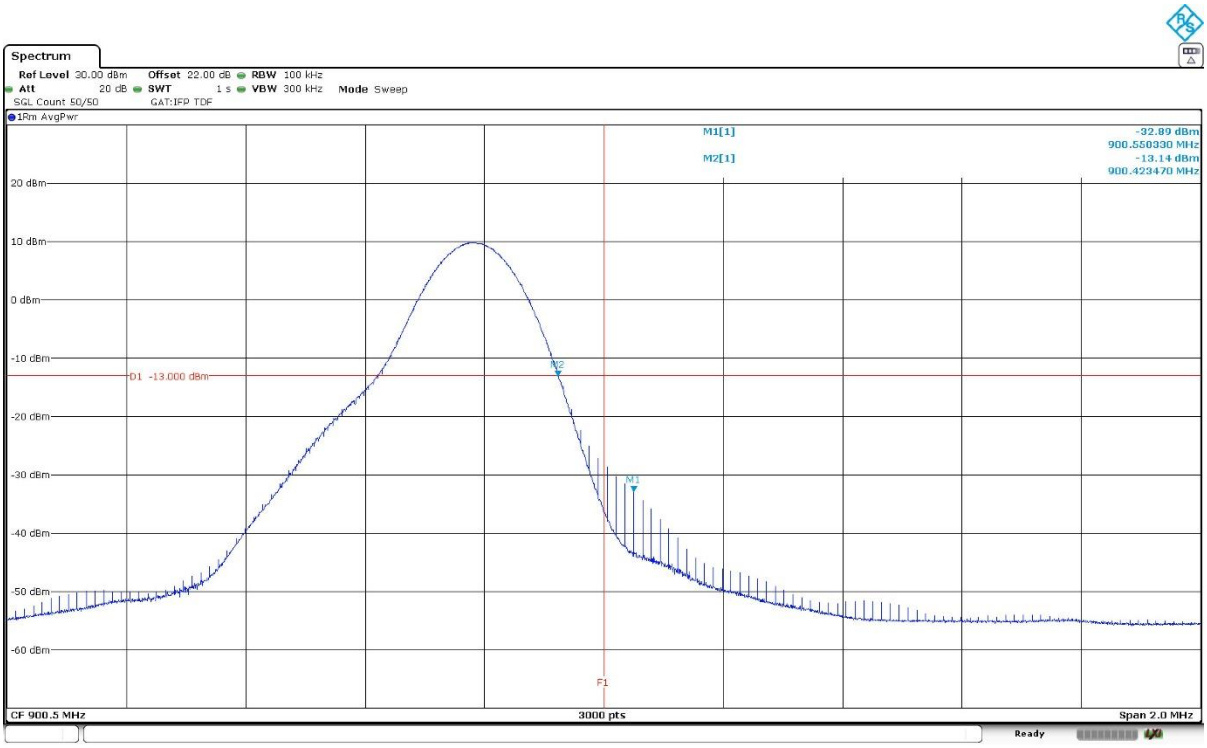
CHANNEL HIGHEST.



NOTE: The equipment transmits at the maximum output power

1 tone of 15kHz, Pi/2-BPSK. Offset=11, MCS / TBS=0

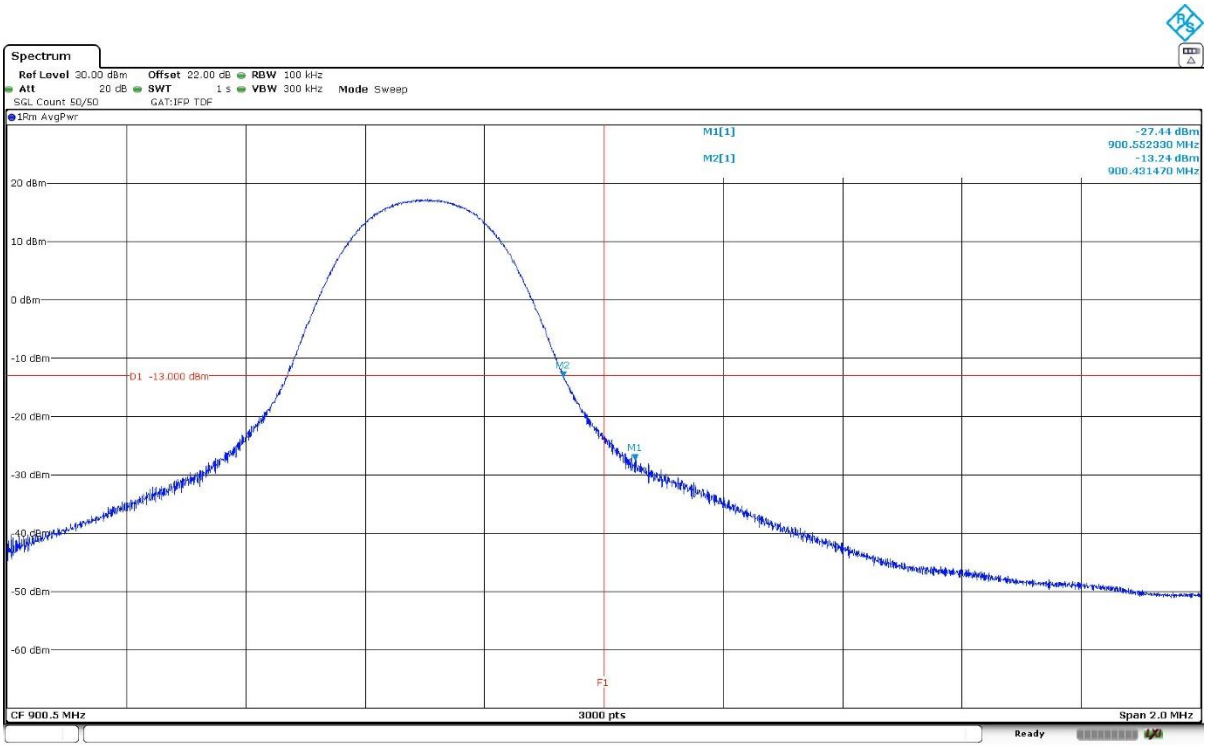
CHANNEL HIGHEST.



NOTE: The equipment transmits at the maximum output power

12 tone of 15kHz, Pi/4-QPSK. Offset=0, MCS / TBS=5

CHANNEL HIGHEST.



NOTE: The equipment transmits at the maximum output power

Verdict: PASS

Radiated Emissions

SPECIFICATION:

LTE Cat M1 Band 8. LTE NB-IoT Band 8. FCC Subpart P §27.1509 (a):

FCC §27.1509 (a):

> (a) The power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) in watts by at least the following amounts:
>
> For 900 MHz broadband operations in 897.5-900.5 MHz band by at least 43 + 10 log (P) dB.

METHOD:

The measurement was performed with the EUT inside an anechoic chamber. The spectrum was scanned from 30 MHz to at least the 10th harmonic of the highest frequency generated within the equipment.

The EUT was placed on a non-conductive stand at a 3 meter distance from the measuring antenna for measurements from 30 MHz up to 10 GHz.

Detected emissions were maximized at each frequency by rotating the EUT and adjusting the measuring antenna height and polarization. The maximum meter reading was recorded.

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:

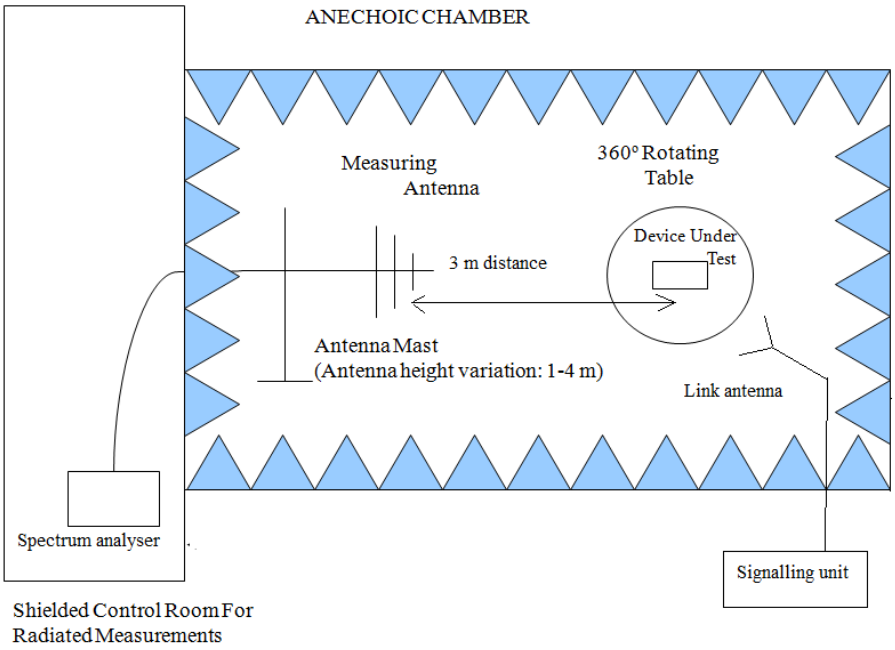
$$EIRP\ (dBm) = E(dB\mu V/m) + 20 \log (D) - 104.8$$

Where D is the measurement distance (in the far field region) in m. D = 3 m.

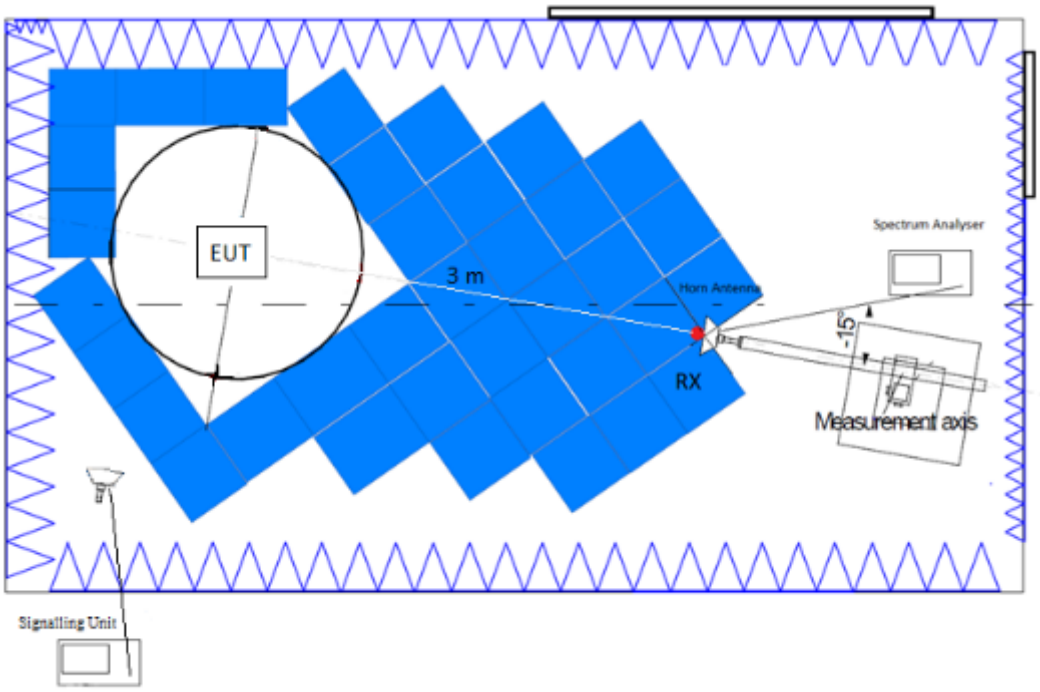
A resolution bandwidth / video bandwidth of 100 kHz / 300 kHz was used for frequencies below 1 GHz and 1 MHz / 3 MHz for frequencies above 1 GHz.

TEST SETUP:

Radiated measurements below 1 GHz.



Radiated measurements between 1 GHz and 10 GHz.



RESULTS:

LTE Cat M1 Band 8:

A preliminary scan determined the QPSK modulation, Nominal Bandwidth of 1.4 MHz, RB Size 1, RB Offset 2 as the worst case. The following tables and plots show the results for this configuration.

- Low Channel:

Frequency range 30 MHz - 1 GHz:

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 10 GHz:

No spurious frequencies at less than 20 dB below the limit.

- Middle Channel:

Frequency range 30 MHz - 1 GHz:

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 10 GHz:

No spurious frequencies at less than 20 dB below the limit.

- High Channel:

Frequency range 30 MHz - 1 GHz:

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 10 GHz:

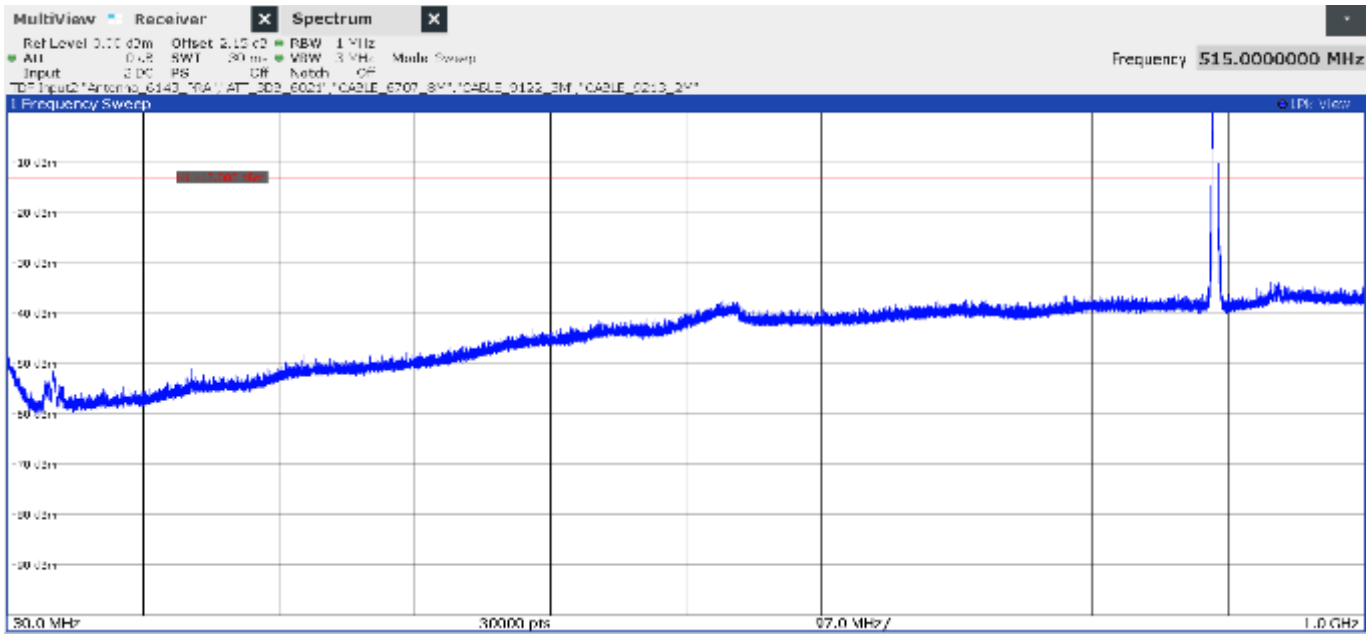
No spurious frequencies at less than 20 dB below the limit.

Measurement Uncertainty (dB):	<± 4.90 for f ≥ 30 MHz up to 1 GHz <± 4.32 for f ≥ 1 GHz up to 10 GHz

Verdict: PASS

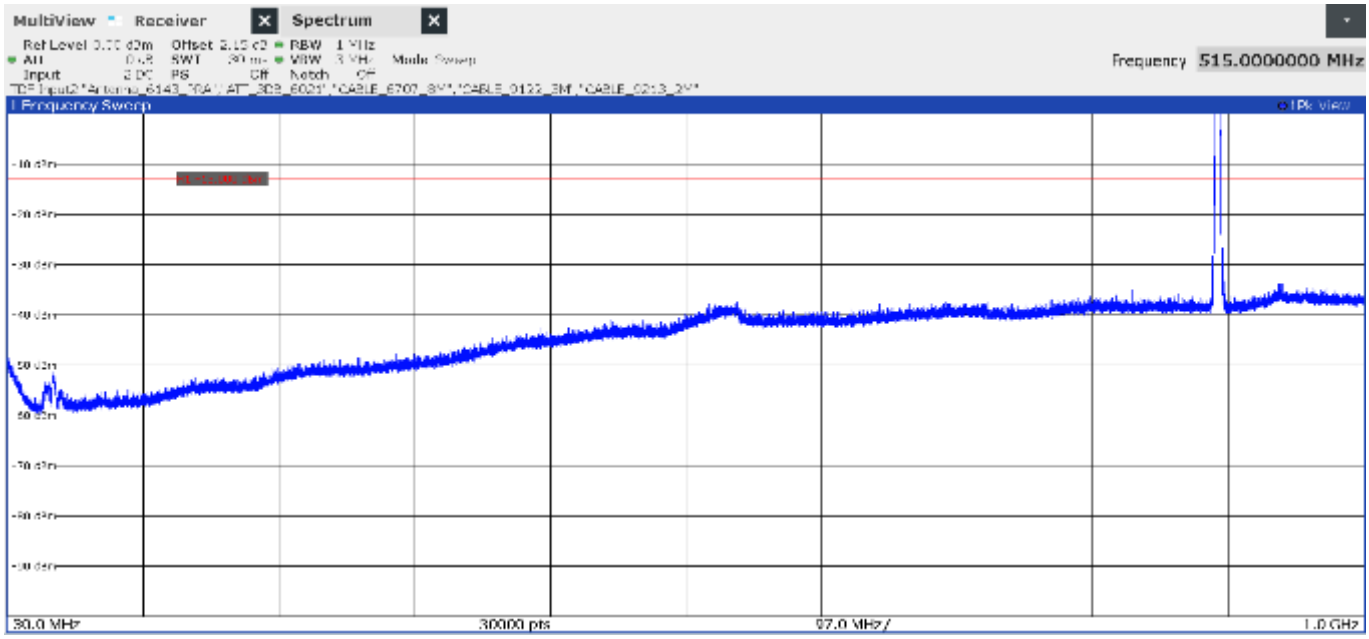
FREQUENCY RANGE 30 MHz - 1 GHz:

- Low Channel:



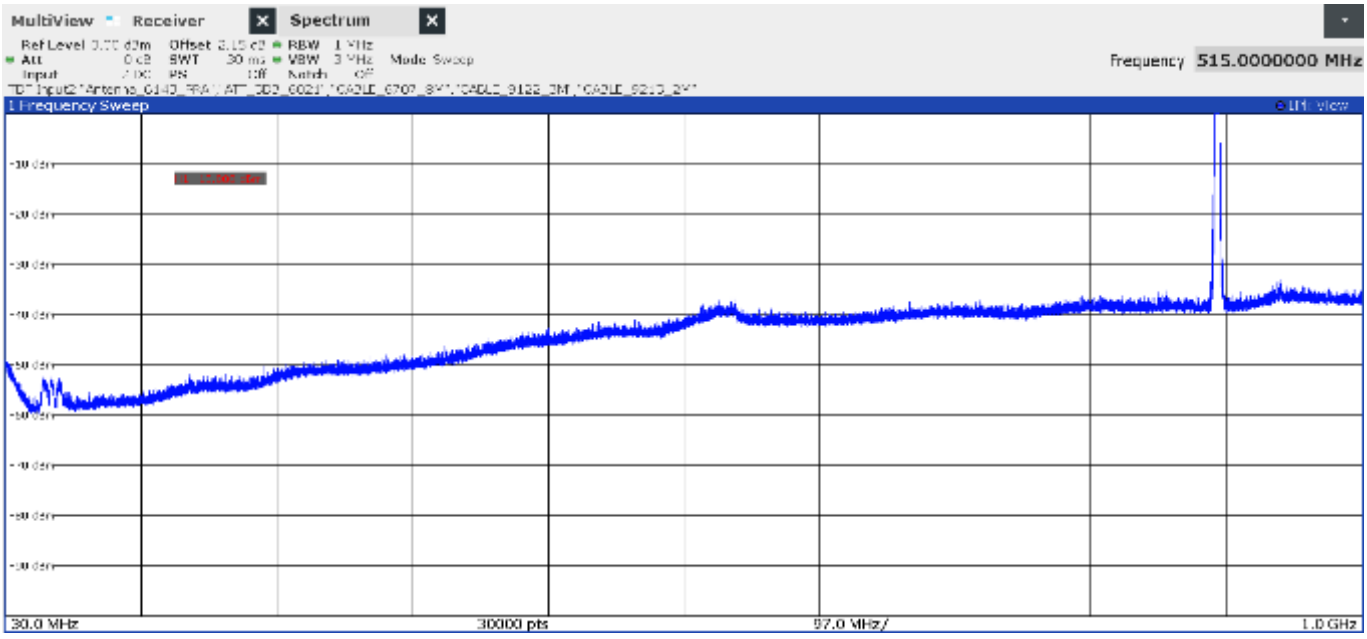
The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.

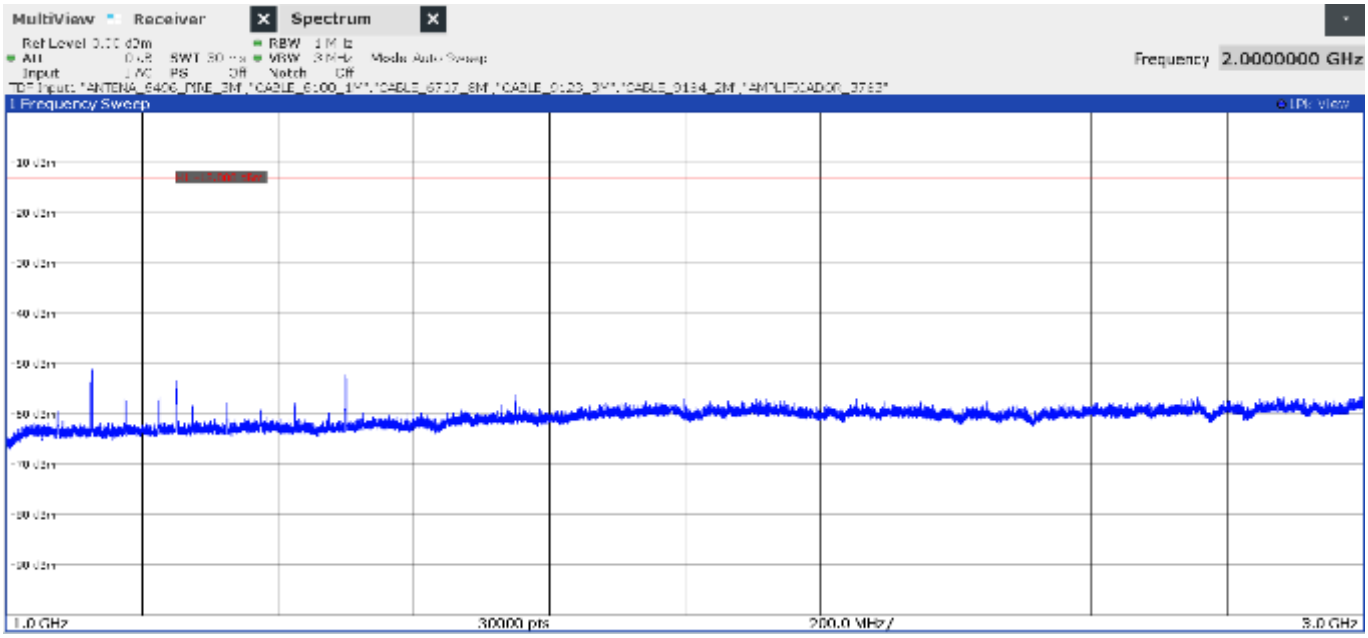
- High Channel:



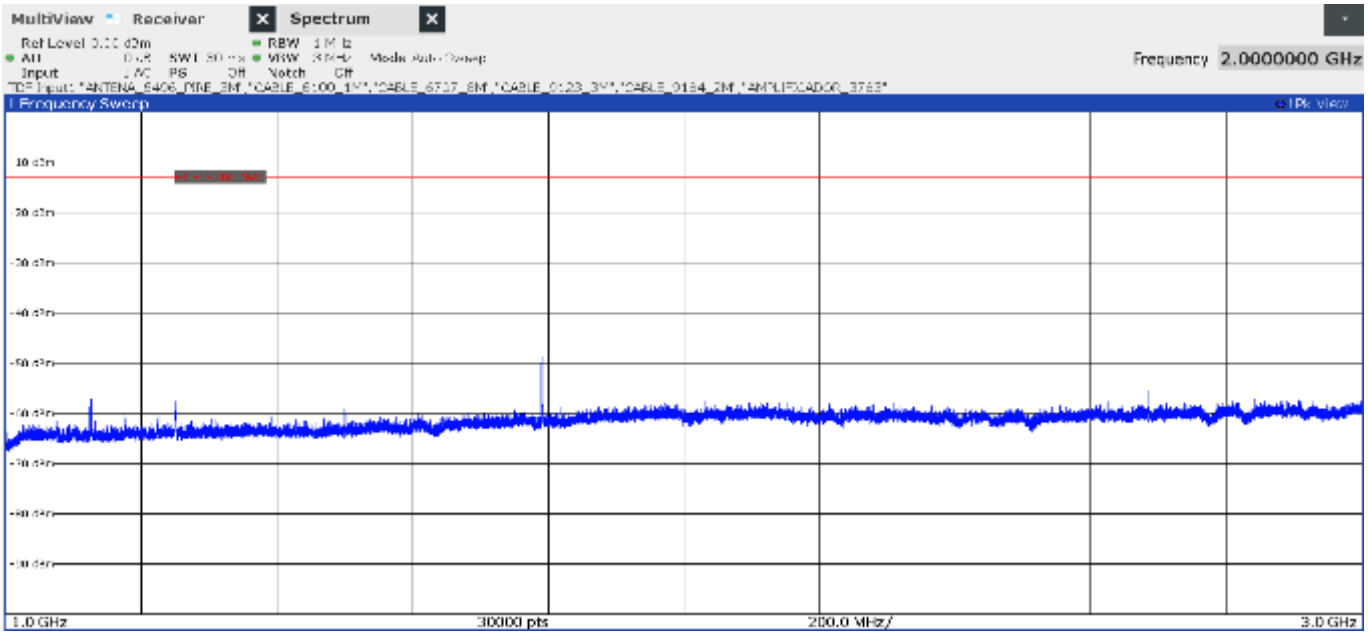
The peak above the limit is the carrier frequency.

FREQUENCY RANGE 1 - 3 GHz:

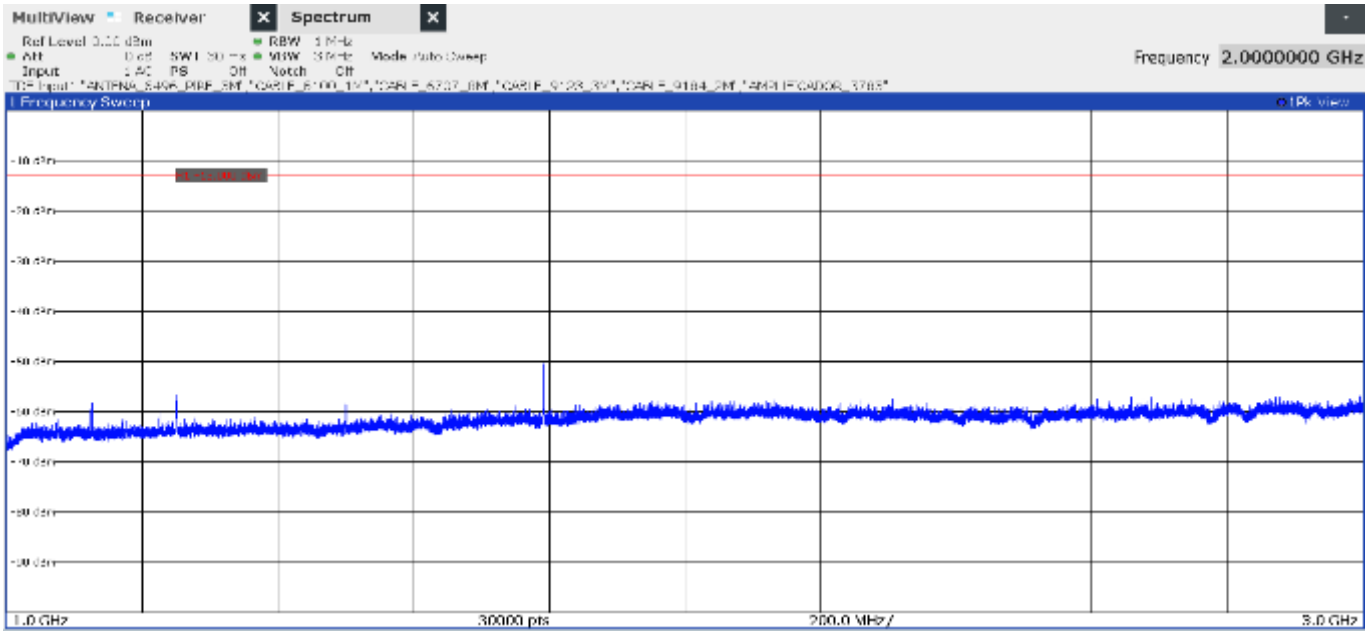
- Low Channel:



- Middle Channel:

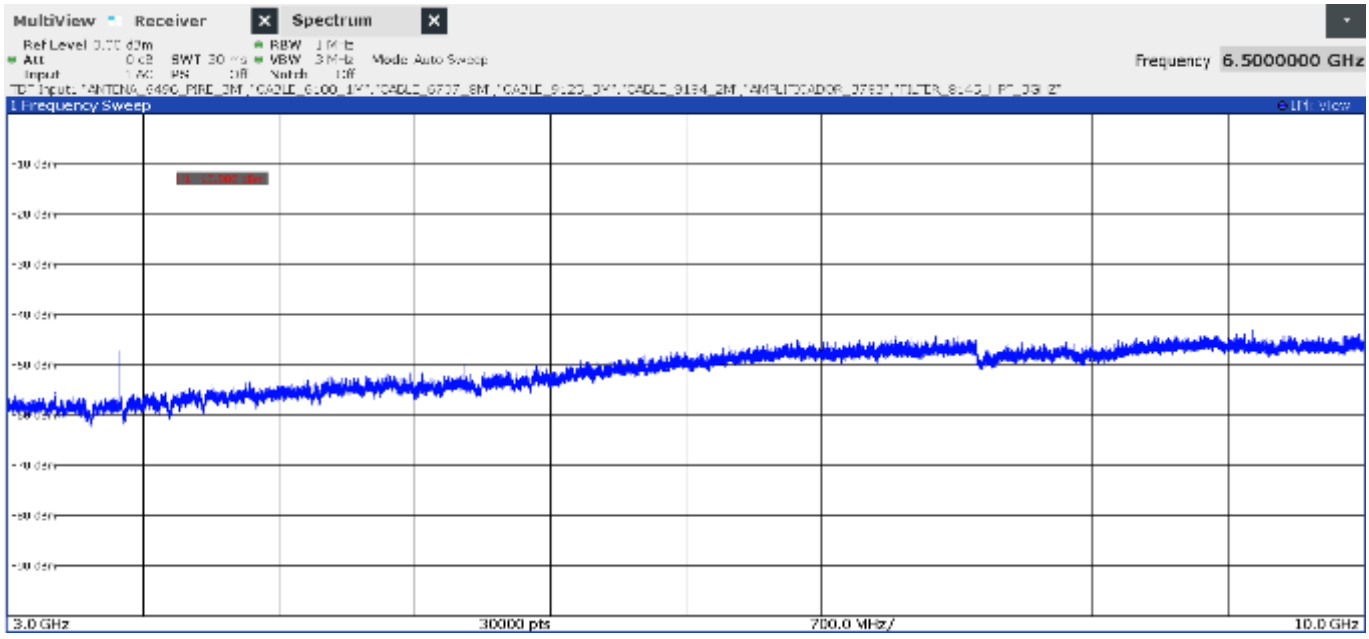


- High Channel:

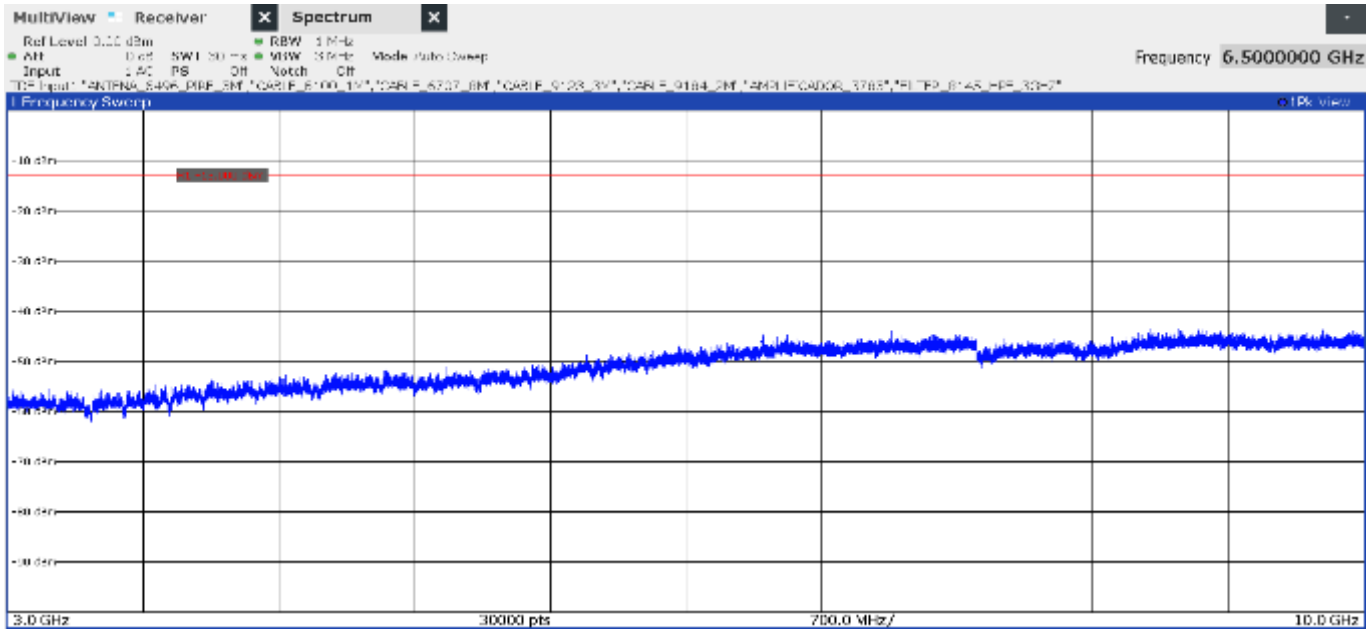


FREQUENCY RANGE 3 - 10 GHz:

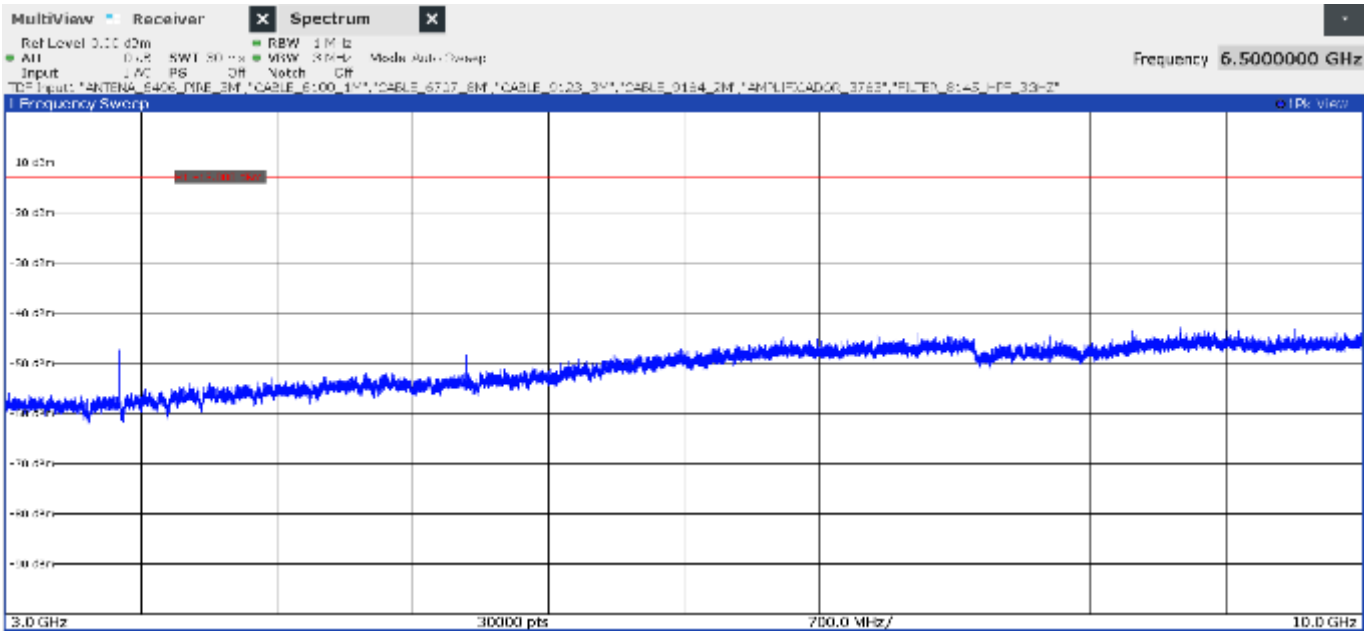
- Low Channel:



- Middle Channel:



- High Channel:



LTE NB-IoT Band 8:

A preliminary scan determined the pi/4-QPSK modulation, Tone Number 1, Tone Channel Bandwidth 3.75 kHz, TBS 3, Tone Offset 0 as the worst case. The following tables and plots show the results for this configuration.

- Low Channel:

Frequency range 30 MHz - 1 GHz:

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 10 GHz:

No spurious frequencies at less than 20 dB below the limit.

- Middle Channel:

Frequency range 30 MHz - 1 GHz:

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 10 GHz:

No spurious frequencies at less than 20 dB below the limit.

- High Channel:

Frequency range 30 MHz - 1 GHz:

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 10 GHz:

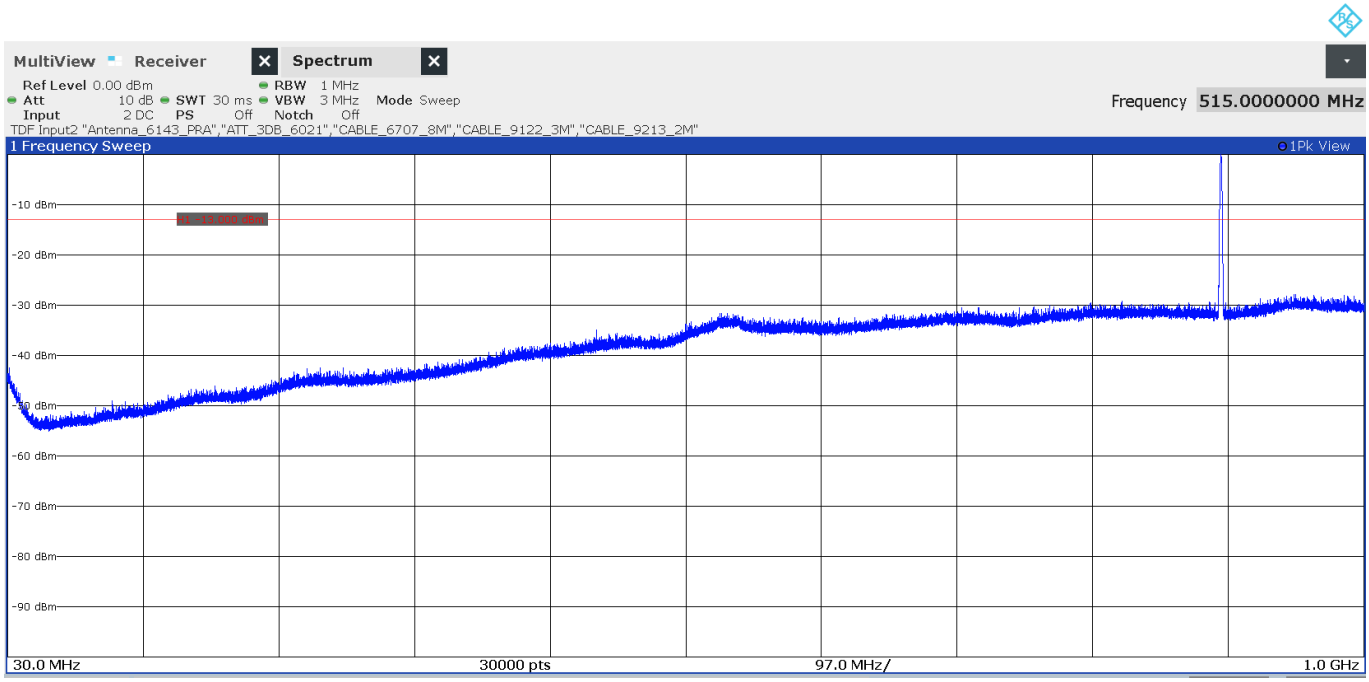
No spurious frequencies at less than 20 dB below the limit.

Measurement Uncertainty (dB):	<± 4.90 for f ≥ 30 MHz up to 1 GHz <± 4.32 for f ≥ 1 GHz up to 10 GHz

Verdict: PASS

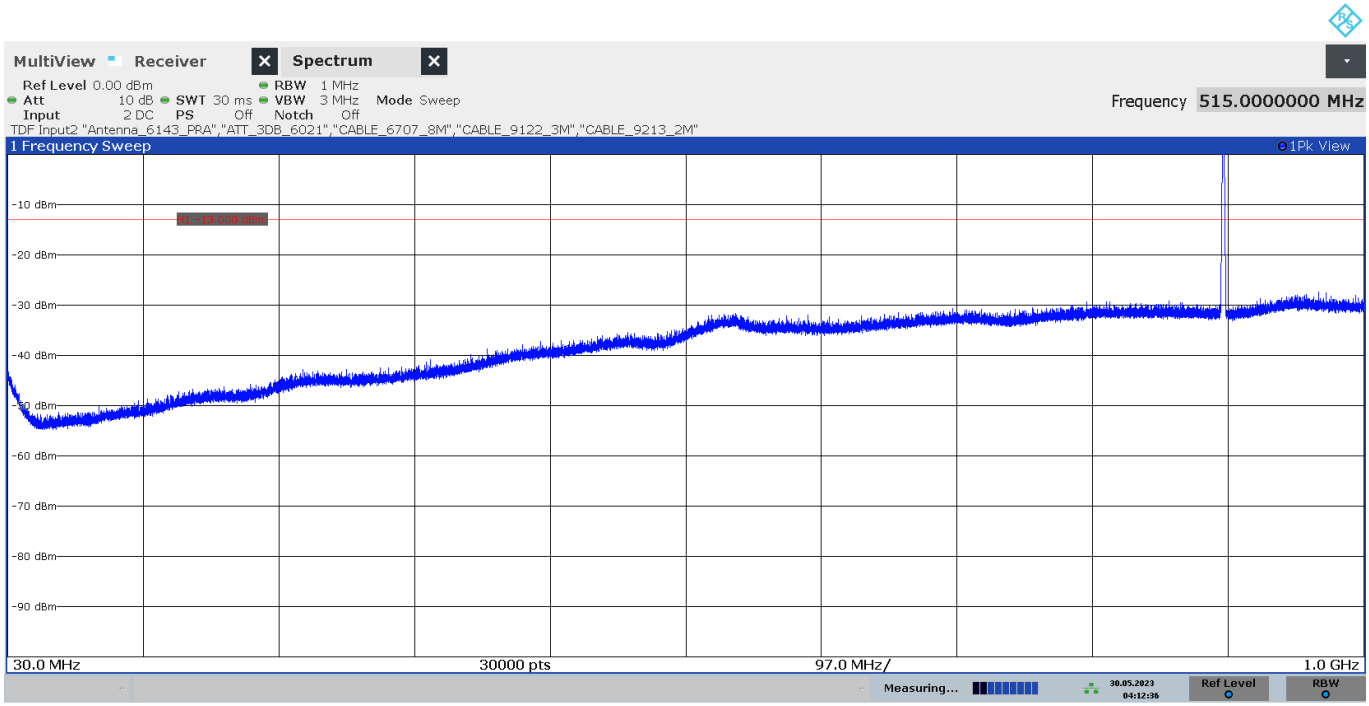
FREQUENCY RANGE 30 MHz - 1 GHz:

- Low Channel:



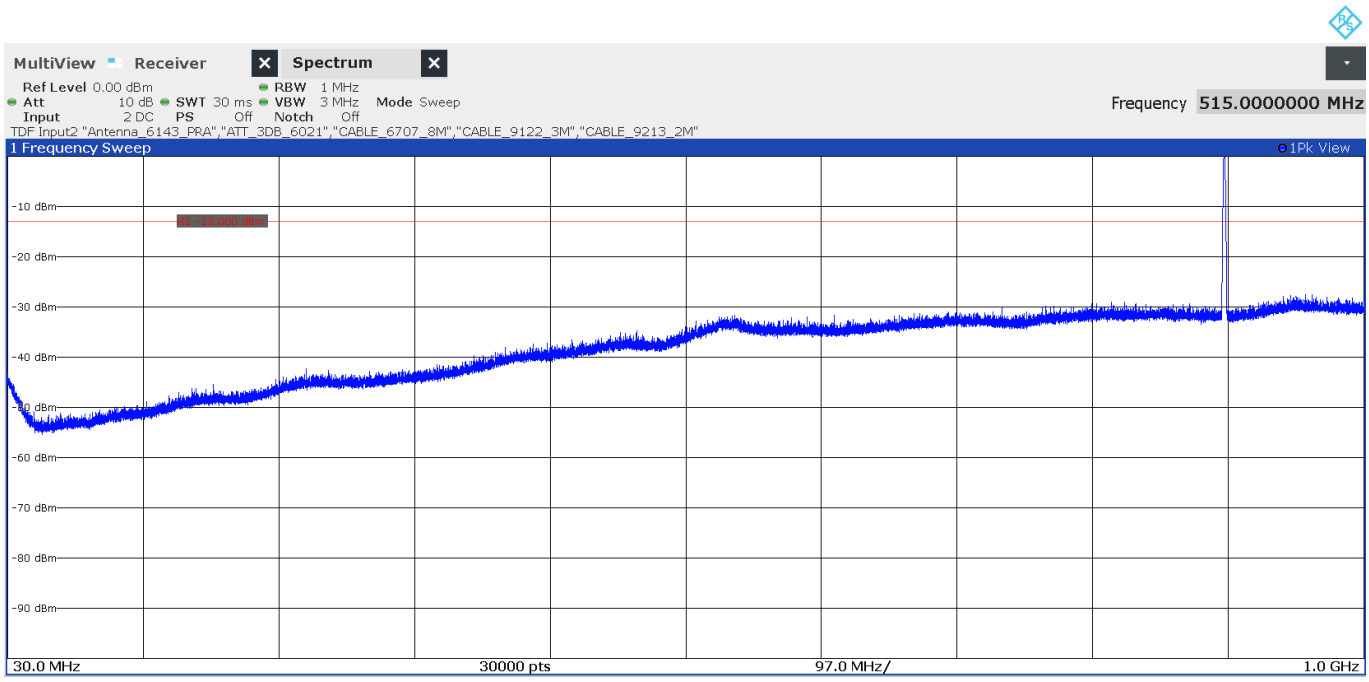
The peak above the limit is the carrier frequency

- Middle Channel:



The peak above the limit is the carrier frequency

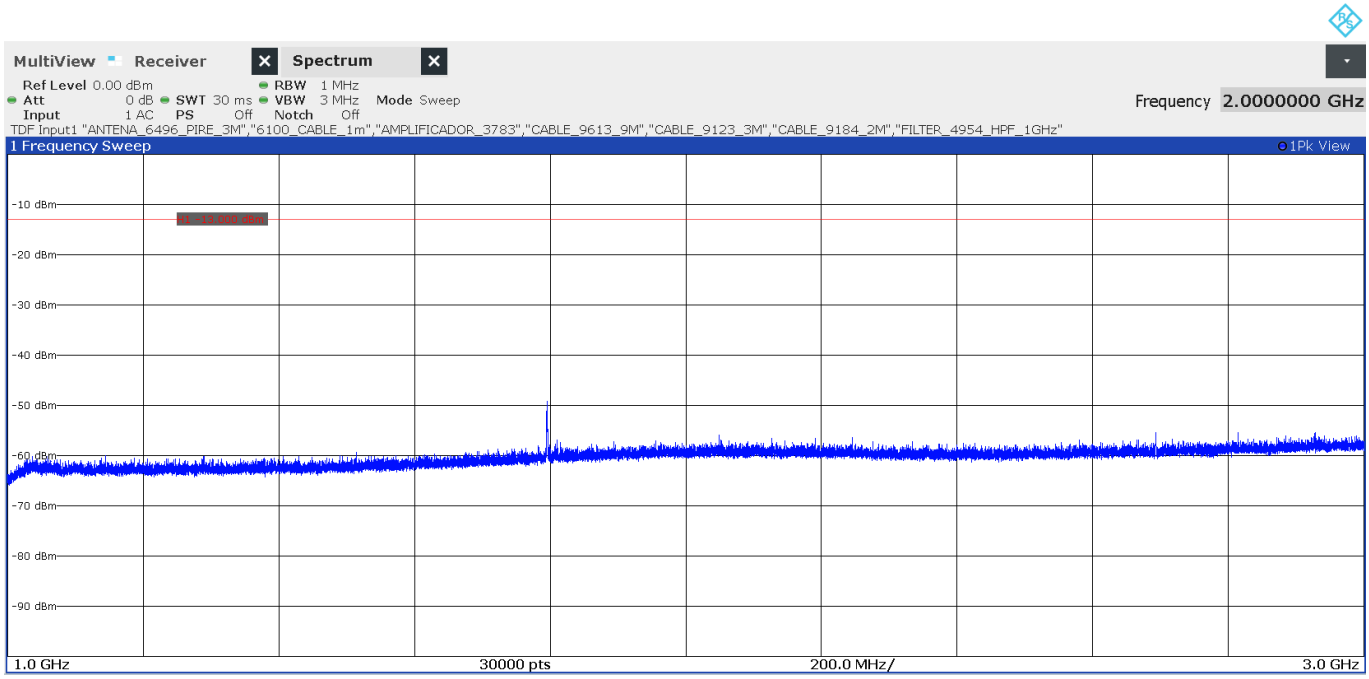
- High Channel:



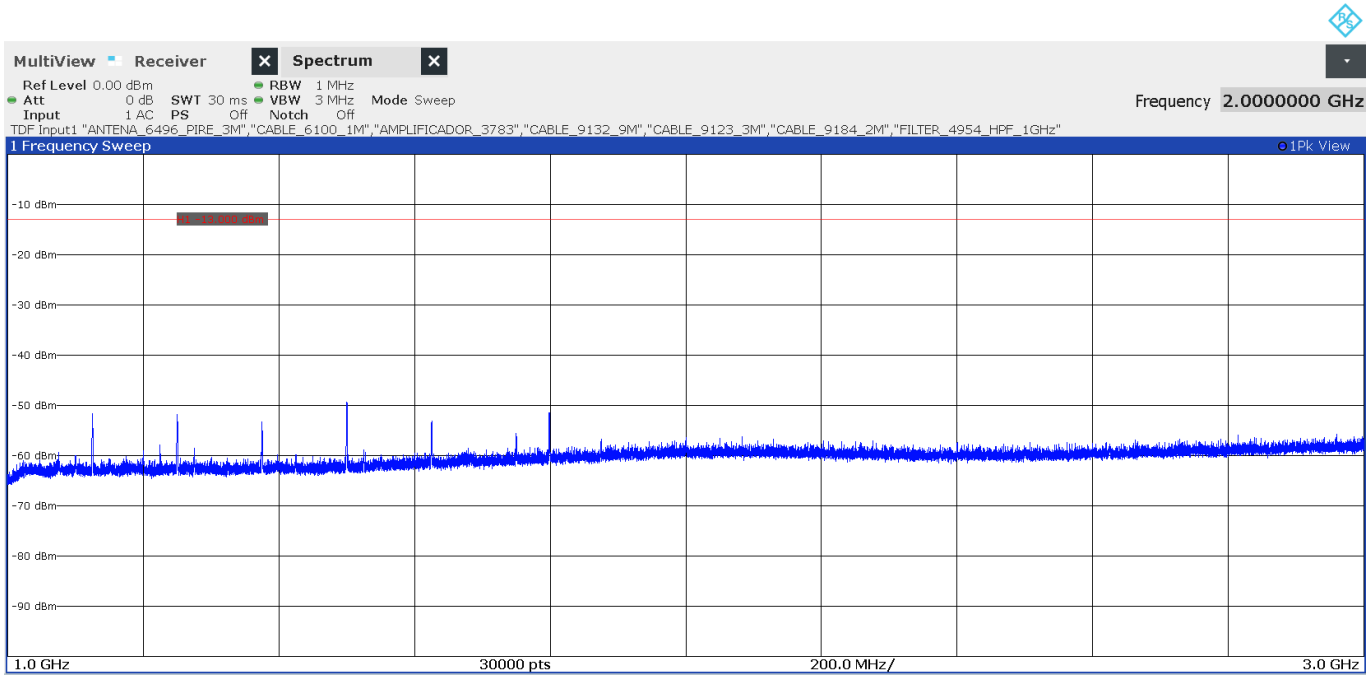
The peak above the limit is the carrier frequency

FREQUENCY RANGE 1 - 3 GHz:

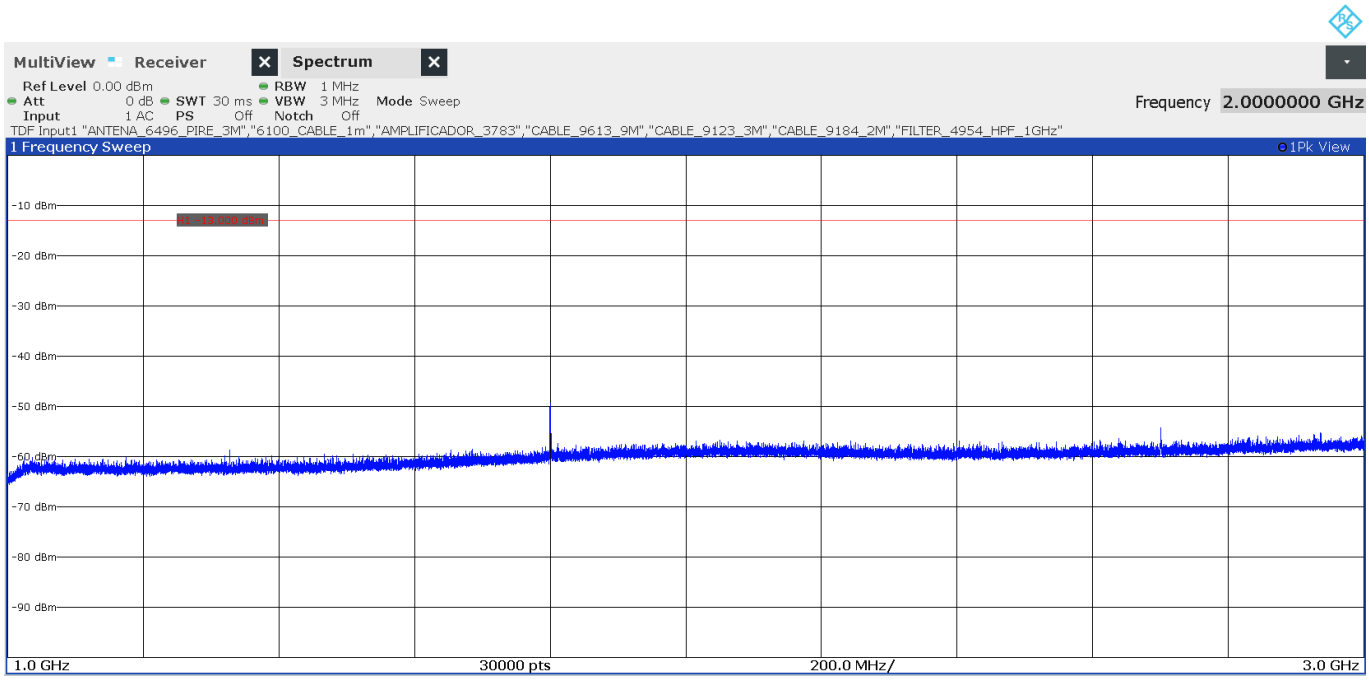
- Low Channel:



- Middle Channel:

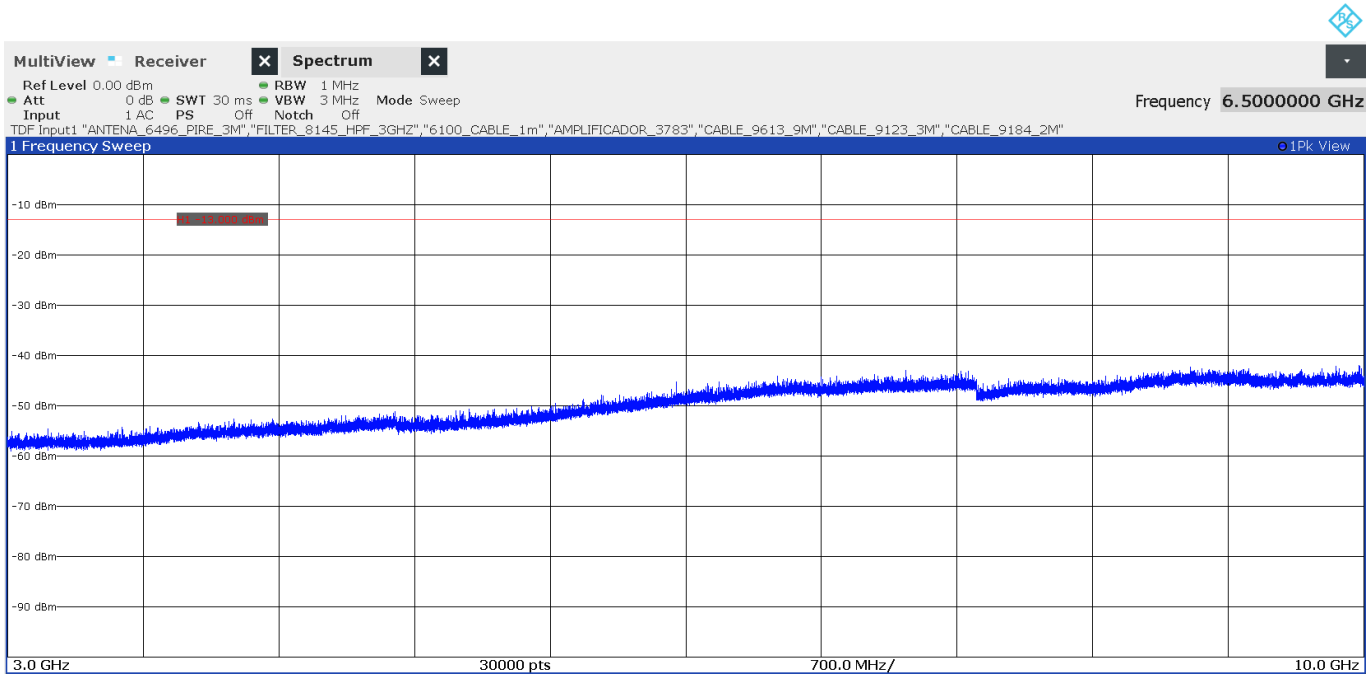


- High Channel:

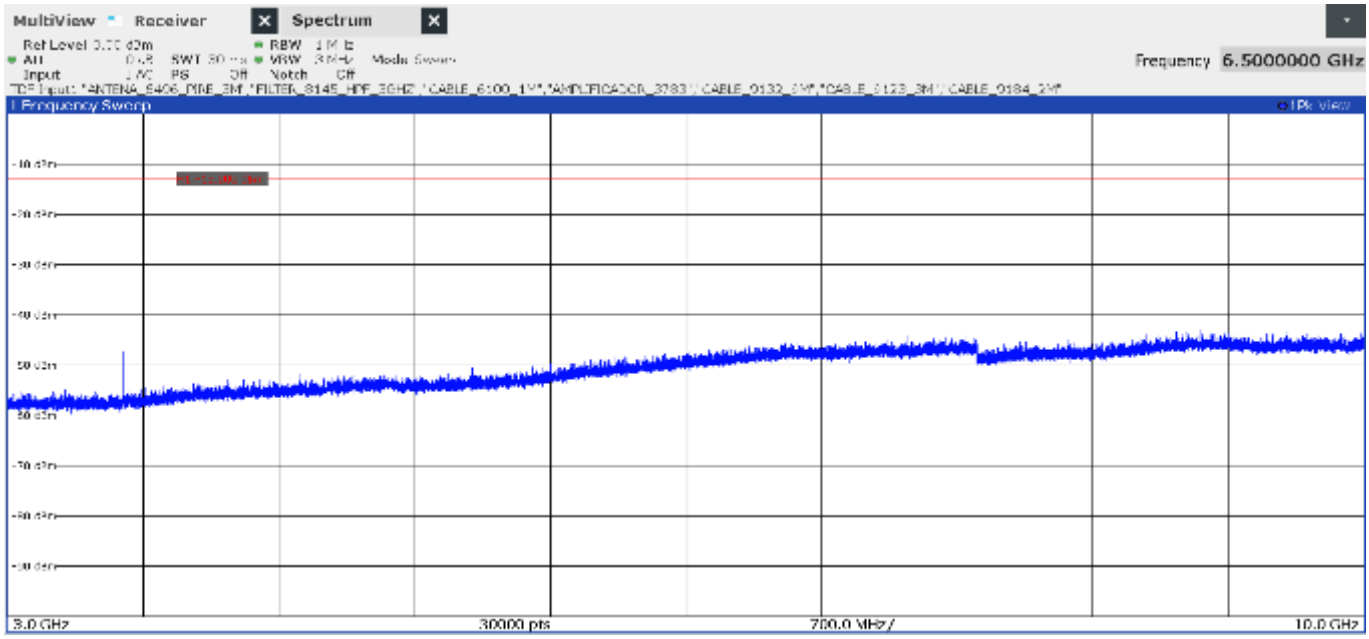


FREQUENCY RANGE 3 - 10 GHz:

- Low Channel:



- Middle Channel:



- High Channel: