

ISED CABid: ES1909
 Lab. Company Number: 4621A

Test Report No:
 75755RRF.002A1

Test Report

USA FCC Part 22

CANADA RSS-132

(*) Identification of item tested	nRF91
(*) Trademark	nRF91
(*) Model and/or type reference	nRF9161
Other identification of the product	FCC ID: 2ANPO00nRF9161 IC: 24529-NRF9161
(*) Features	LTE Cat-M1, LTE NB1&NB2 HW version: nRF9161 LACA A0A SW version: mfw_nrf91x1_2.0.0-77.beta
Applicant	NORDIC SEMICONDUCTOR ASA Otto Niensens Veg 12, 7052 Trondheim, Norway
Test method requested, standard	USA FCC Part 22 (10-1-21 Edition). CANADA RSS-132 Issue 4, Jan. 2023. ANSI C63.26-2015. 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
Date of issue	2023-11-30
Report template No	FDT08_24 (* "Data provided by the client")

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Competences and guarantees

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DEKRA Testing and Certification is an FCC-recognized accredited testing laboratory with appropriate scope of accreditation that covers the performed tests in this report.

DEKRA Testing and Certification is an ISED-recognized accredited testing laboratory, CABid: ES1909, Company Number: 4621A, 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 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 model nRF9161 is a Development Kit that has nRF9161 IOT Module and GPS. The nRF9161 is capable of LTE Cat-M1, Cat-NB1&NB2 and GPS. The Development kit contains antennas for cellular and GPS.

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 N°	Description	Model	Serial N°	Date of reception
75755B/005	nRF91	nRF9161	359746166778998	11-05-2023
75755B/007	USB Cable	-	-	11-05-2023

Sample S/01 has undergone the following test(s): The radiated tests indicated in Appendix A and B.

- Sample S/02 is composed of the following elements:

Control N°	Description	Model	Serial N°	Date of reception
75755B/003	nRF91	nRF9161	359746166783618	11-05-2023
75755B/007	USB Cable	-	-	11-05-2023
75755B/011	Antenna Cable SMA	-	-	11-05-2023

Sample S/02 has undergone the following test(s): The conducted tests indicated in Appendix A and B.

Test sample description

Ports.....:	Port name and description	Cable					
		Specified max length [m]	Attached during test	Shielded	Coupled to patient ⁽³⁾		
		LTE RF	2	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
		GPS	2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Supplementary information to the ports.....:	-						
Rated power supply	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	<input type="checkbox"/>	AC:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	AC:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<input checked="" type="checkbox"/>	DC: 3.0-5.5V					
<input type="checkbox"/>	DC:						
Rated Power.....:	1W						
Clock frequencies.....:	32kHz, 32MHz						
Other parameters	-						
Software version.....:	mfw_nrf91x1_2.0.0-77.beta						
Hardware version	nRF9161 LACA A0A						
Dimensions in cm (W x H x D) ...:	155x64x9mm						
Mounting position	<input checked="" type="checkbox"/>	Table top equipment					
	<input type="checkbox"/>	Wall/Ceiling mounted equipment					
	<input type="checkbox"/>	Floor standing equipment					
	<input type="checkbox"/>	Hand-held equipment					
	<input type="checkbox"/>	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 Niensens Veg 12, 7052 Trondheim, Norway

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2023-05-15
Date (finish)	2023-08-23

Document history

Report number	Date	Description
75755RRF.002	2023-09-21	First release.
75755RRF.002A1	2023-11-30	Second release. Minor typos corrected. Corrections in RBW used for block edges measurement. This release cancel and replace 75755RRF.002

Environmental conditions

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

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

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

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

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

Temperature	Min. = 15 °C Max. = 35 °C
--------------------	------------------------------

Relative humidity

Min. = 20 %
Max. = 75 %

Remarks and comments

The tests have been performed by the technical personnel: Rafael Fernández, Pablo Redondo and Sergio Carrasco,

Used instrumentation:

Control No.	Equipment	Model	Manufacturer	Next Calibration
6791	SEMIANECHOIC ABSORBER LINED	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
3783	PRE-AMPLIFIER G>30dB 1GHz-18GHz	BLMA 0118-3A	BONN ELEKTRONIK	2023-12
6496	HORN ANTENNA 1-18GHz	BBHA 9120 D	SCHWARZBECK	2023-08
6143	Biconical/Log Antenna 30 MHz - 6 GHz	3142E	ETS LINDGREN	2023-10
9229	Wideband Radio Communication Tester	CMW500	ROHDE AND SCHWARZ	2024-06
7794	Signal and Spectrum Analyzer 10 Hz - 40 GHz	FSV40	ROHDE AND SCHWARZ	2025-04
6794	Shielded Room	S101	ETS LINDGREN	N/A
7817	EMI Test Receiver 2 Hz - 44 GHz	ESW44	ROHDE AND SCHWARZ	2023-12
8912	Wideband Radio Communication Tester	CMW500	ROHDE AND SCHWARZ	2023-09
8002	TEMPERATURE CHAMBER MK56 BINDER	MK 56	BINDER	2024-04
5880	DC POWER SUPPLY 30V/5A	U8002A	KEYSIGHT TECHNOLOGY	N/A
5850	DIGITAL MULTIMETER	179	DIGITAL MULTIMETER	2023-11
4848	SOFTWARE FOR EMC/RF TESTING	EMC32	ROHDE AND SCHWARZ	N/A

Testing verdicts

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

Summary

Appendix A: LTE Cat-M1 Bands 5, 26.

FCC PART 22 / RSS-132 PARAGRAPH		
Requirement – Test case	Verdict	Remark
FCC 22.913 / RSS-132 5.4: RF Output Power	P	
FCC 2.1047 / RSS-132 5.2: Modulation Characteristics	P	
FCC 22.355 / RSS-132 5.3: Frequency Stability	P	
FCC 2.1049: Occupied Bandwidth	P	
FCC 22.917 / RSS-132 5.5: Spurious Emissions at Antenna Terminals	P	
FCC 22.917 / RSS-132 5.5: Spurious Emissions at Antenna Terminals at Block Edges	P	
FCC 22.917 / RSS-132 5.5: Radiated Emissions	P	
<u>Supplementary information and remarks:</u> None.		

Appendix B: LTE Cat NB1 Bands 5, 26.

FCC PART 22 / RSS-132 PARAGRAPH		
Requirement – Test case	Verdict	Remark
FCC 22.913 / RSS-132 5.4: RF Output Power	P	
FCC 2.1047 / RSS-132 5.2: Modulation Characteristics	P	
FCC 22.355 / RSS-132 5.3: Frequency Stability	P	
FCC 2.1049: Occupied Bandwidth	P	
FCC 22.917 / RSS-132 5.5: Spurious Emissions at Antenna Terminals	P	
FCC 22.917 / RSS-132 5.5: Spurious Emissions at Antenna Terminals at Block Edges	P	
FCC 22.917 / RSS-132 5.5: Radiated Emissions	P	
<u>Supplementary information and remarks:</u> None.		

Appendix A: Test results for FCC 22 / RSS-132: LTE Cat-M1 Bands 5, 26

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TEST CONDITIONS

(*): Declared by the Applicant.

POWER SUPPLY (*):

Vnormal: 5 Vdc.
 Vmin 3 Vdc
 Vmax 5.5Vdc
 Type of Power Supply: Internal DC.

ANTENNA (*):

Bands	Gain (dBi)	Type
LTE 5	+2.7	SMD
LTE 26	+2.7	SMD

TEST FREQUENCIES:

LTE Cat-M1 Band 5. QPSK and 16QAM:

	Channel (Frequency MHz)			
	BW=1.4 MHz	BW=3 MHz	BW=5 MHz	BW=10 MHz
Low	20407 (824.70)	20415 (825.50)	20425 (826.50)	20450 (829.00)
Middle	20525 (836.50)	20525 (836.50)	20525 (836.50)	20525 (836.50)
High	20643 (848.30)	20635 (847.50)	20625 (846.50)	20600 (844.00)

NOTE: The 824-849 MHz sub-band of the LTE Cat-M1 Band 5 is completely included in the LTE Cat-M1 Band 26, so the LTE Cat-M1 Band 26 channels were tested to give conformity to the assigned block.

LTE Cat-M1 Band 26 sub-band 824-849 MHz. QPSK and 16QAM:

	Channel (Frequency MHz)				
	BW=1.4 MHz	BW=3 MHz	BW=5 MHz	BW=10 MHz	BW=15 MHz
Low	26797 (824.70)	26805 (825.50)	26815 (826.50)	26840 (829.00)	26865 (831.50)
Middle	26915 (836.50)	26915 (836.50)	26915 (836.50)	26915 (836.50)	26915 (836.50)
High	27033 (848.30)	27025 (847.50)	27015 (846.50)	26990 (844.00)	26965 (841.50)

RF Output Power

Limits

FCC §2.1046 and FCC §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.).

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

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:

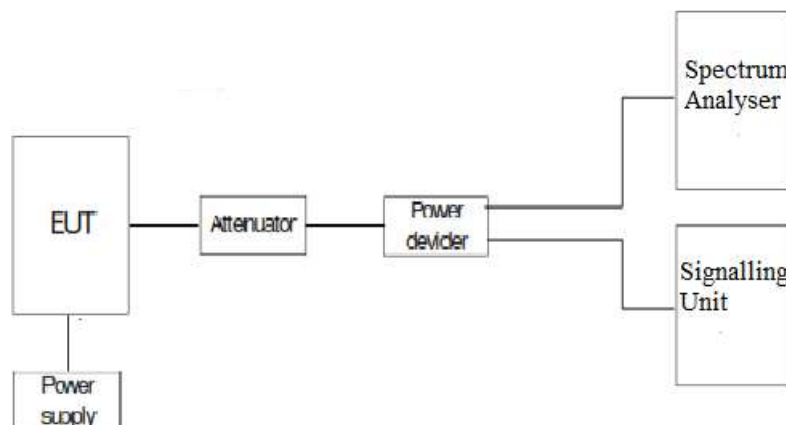
$$E.R.P. = E.I.R.P. - 2.15 \text{ dB}$$

Test Setup

1. CONDUCTED AVERAGE POWER:



2. PEAK-TO-AVERAGE POWER RATIO (PAPR) and Conducted Average power:



Results

1. CONDUCTED AVERAGE POWER:

LTE Cat-M1 Band 26:

Preliminary measurements determined the worst case of RF Power is BW=15 MHz, High Channel, 16QAM, RB Size=1, RB Offset=2, Narrow Band=0.

BANDWIDTH (MHz)	CHANNEL	FREQUENCY (MHz)	MODULATION	RB SIZE	RB OFFSET	AVERAGE POWER (dBm)
15	Low 26865	831.5	QPSK	1	0	22.63
				1	2	22.63
				1	5	22.63
				3	0	22.74
				3	1	22.74
				3	3	22.74
			6	0	22.66	
			16QAM	1	0	22.56
				1	2	22.57
				1	5	22.57
				3	0	22.89
				3	1	22.88
	3	3		22.75		
	Middle 26915	836.5	QPSK	1	0	22.72
				1	2	22.74
				1	5	22.74
				3	0	22.75
				3	1	22.74
				3	3	22.74
			6	0	22.73	
			16QAM	1	0	22.8
				1	2	22.81
				1	5	22.81
				3	0	22.9
3				1	22.91	
3	3	22.91				
High 26965	841.5	QPSK	1	0	22.56	
			1	2	22.56	
			1	5	22.56	
			3	0	22.62	
			3	1	22.6	
			3	3	22.61	
		6	0	22.79		
		16QAM	1	0	23.07	
			1	2	23.13	
			1	5	23.13	
			3	0	22.97	
			3	1	22.99	
3	3		22.99			
5	0	22.66				

BW=15 MHz. QPSK modulation:

MAX POWER	QPSK COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG EIRP(dBm)
LOW	22.74	2.7	25.44
MIDDLE	22.75	2.7	25.45
HIGH	22.79	2.7	25.49
MAX:	22.79		25.49

BW=15 MHz. 16QAM:

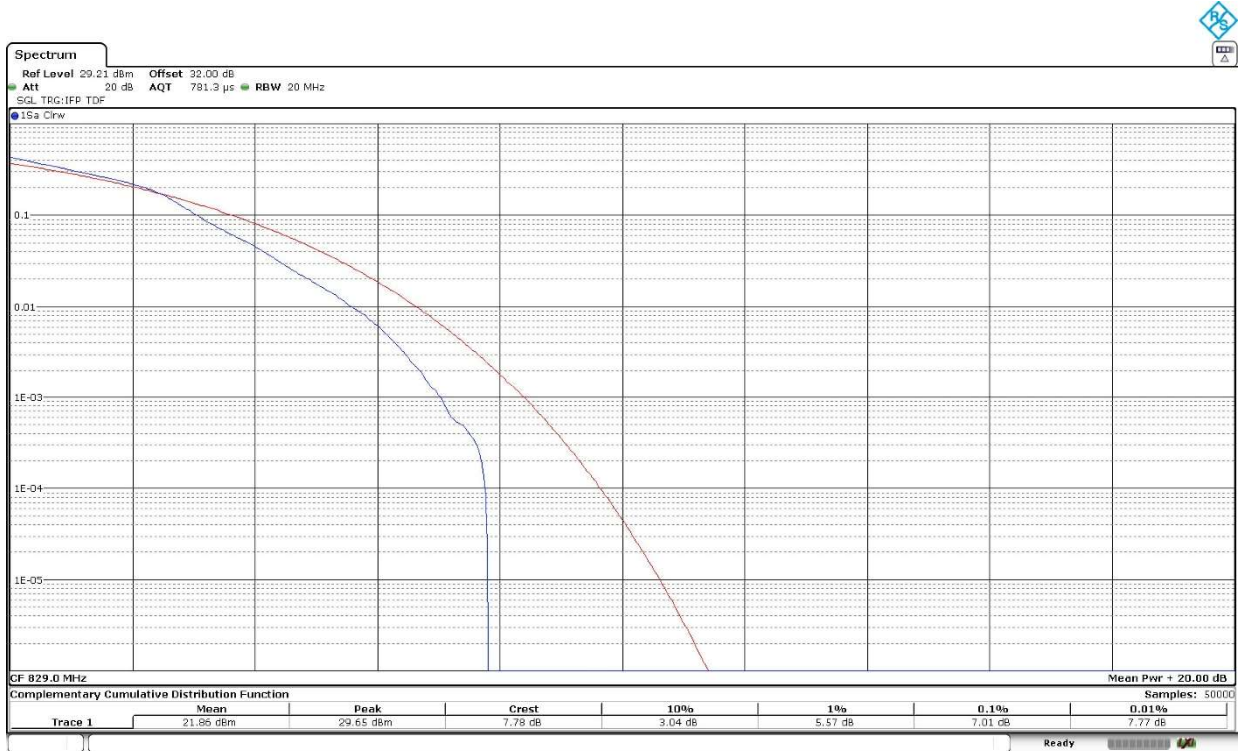
MAX POWER	16QAM COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG EIRP(dBm)
LOW	22.89	2.7	25.59
MIDDLE	22.91	2.7	25.61
HIGH	23.13	2.7	25.83
MAX:	23.13		25.83

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

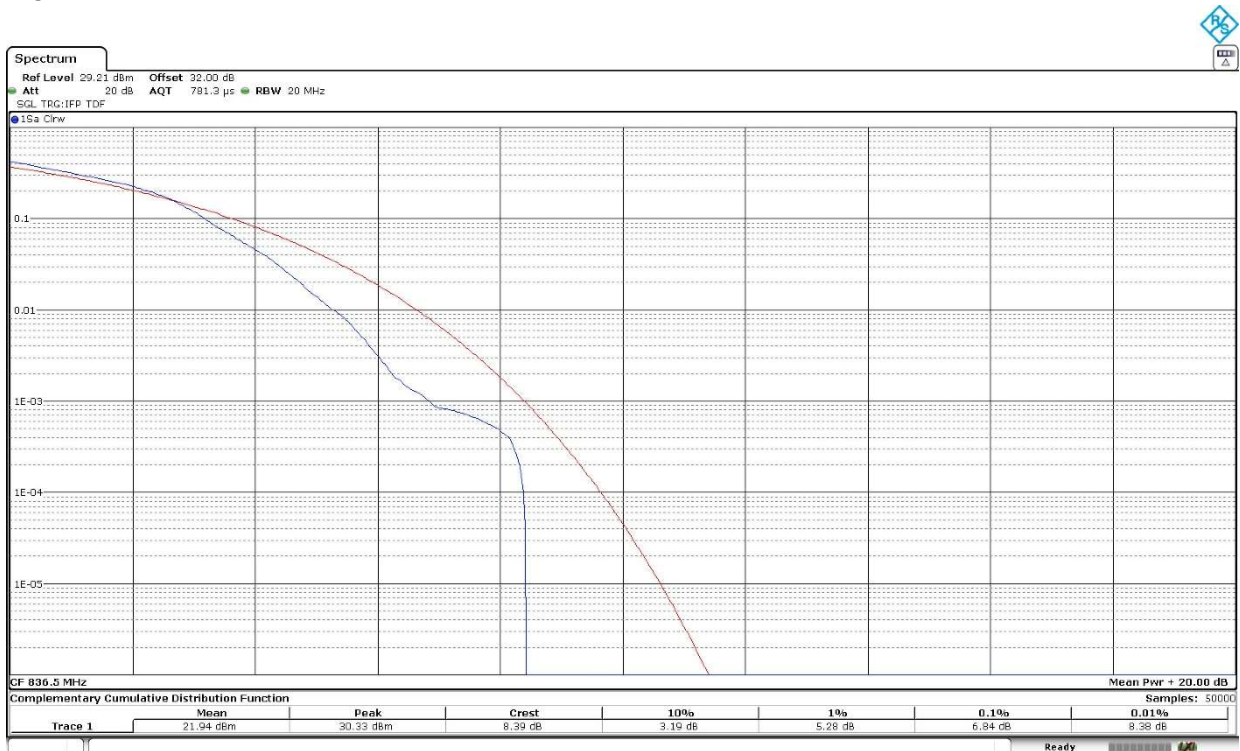
LTE Cat-M1 Band 26:

Preliminary measurements determined the worst-case of PAPR is BW=10 MHz, Middle Channel, 16QAM, RB Size=5, RB Offset=0, Narrow Band=0.

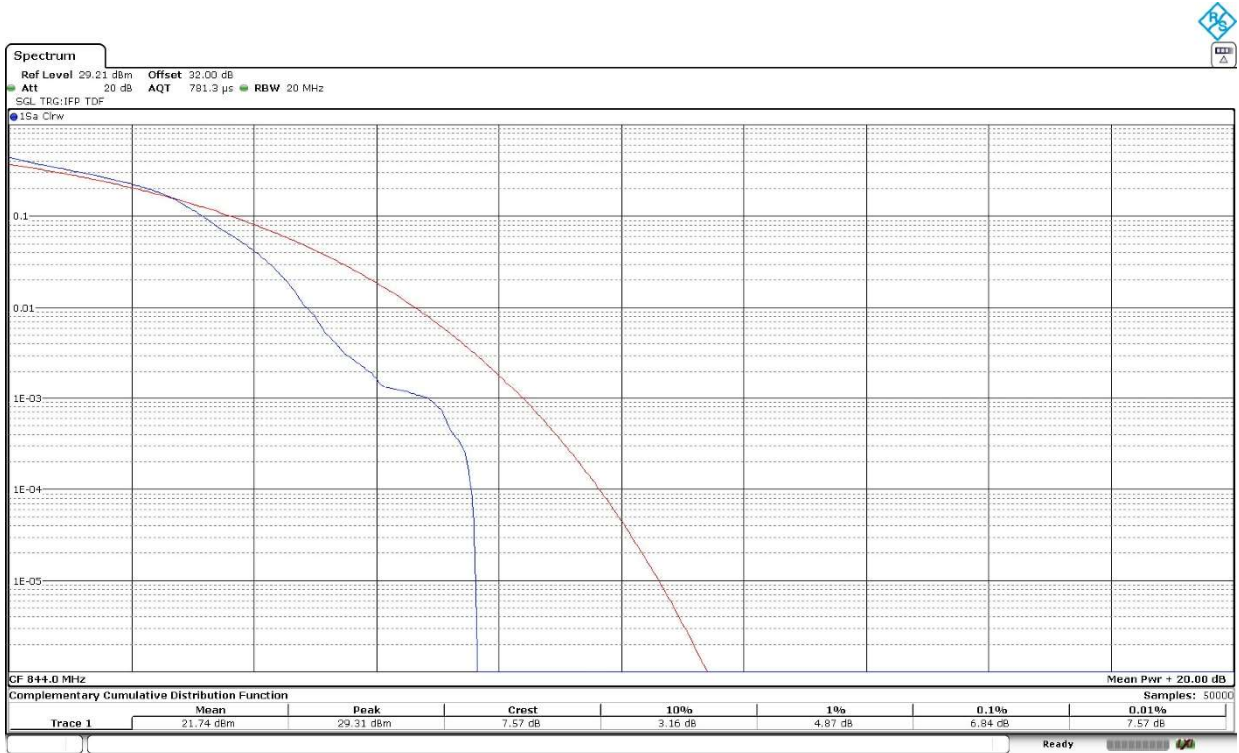
Low Channel:



Middle Channel:



High Channel:



16QAM	Low	Middle	High
PAPR (dB)	7.01	6.84	6.84

Measurement uncertainty (dB) <±1.11

Verdict

Pass

Frequency Stability

Limits

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 -30°C to $+50^{\circ}\text{C}$. The EUT was placed inside a climatic chamber and the temperature was raised hourly in 10°C steps from -30°C up to $+50^{\circ}\text{C}$.

The supply voltage was varied between 85% and 115% of nominal voltage.

Temperature and voltage range of testing has been extended to the maximum and minimum values declared by customer.

The EUT was set in "Radio Resource Control (RRC) mode" 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.

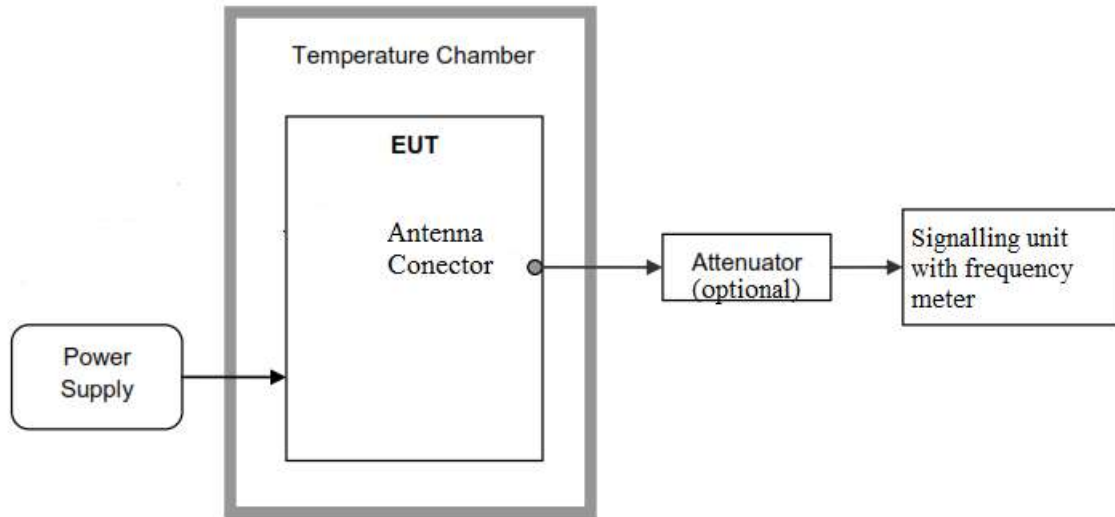
The worst-case LTE mode for conducted power was used for the test.

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 LOW and HIGH 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.

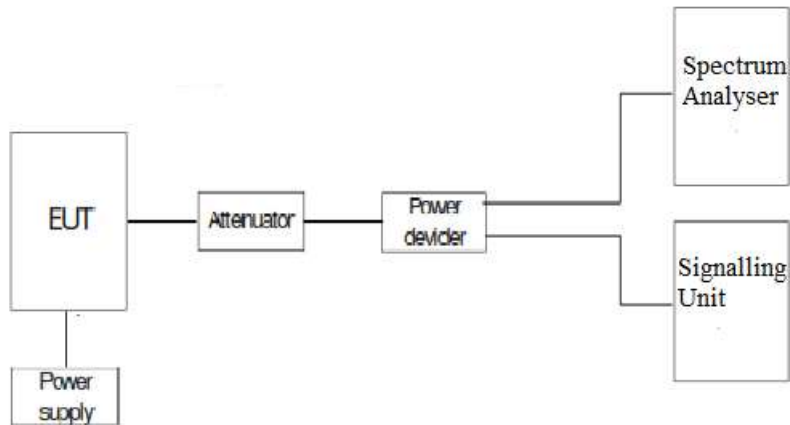
The reference point measurements were made at the RF output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

Test Setup

Frequency tolerance:



Reference points f_L and f_H :



Results

LTE Cat-M1 Band 26:

The worst case modulation in terms of Frequency Stability is BW=1.4 MHz, QPSK.

1. Frequency Tolerance:

- Frequency Stability over Temperature Variations:

Temperature (°C)	Frequency Error (Hz)	Frequency Error (ppm)
+85	2,43	0,002904961
+80	4,57	0,00546324
+70	-3,64	-0,004351464
+60	-7,16	-0,008559474
+50	-4,32	-0,005164375
+40	3,78	0,004518828
+30	-4,28	-0,005116557
+20	3,4	0,004064555
+10	-4,58	-0,005475194
0	8,14	0,009731022
-10	7,7	0,009205021
-20	6,42	0,007674836
-30	-5,08	-0,006072923
-40	-0,94	-0,00112373

- Frequency Stability over Voltage Variations.

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	2.33	0.002785415
Vmin	3	-9,53	-0,011392708

2. Reference Frequency Points fL and fH:

The worst-case frequency offsets added or subtracted per band and bandwidth:

fL (MHz)	824.0277
fH (MHz)	848.9640

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

Measurement uncertainty (Hz) $< \pm 249.55$

Verdict

Pass

Modulation Characteristics

Limits

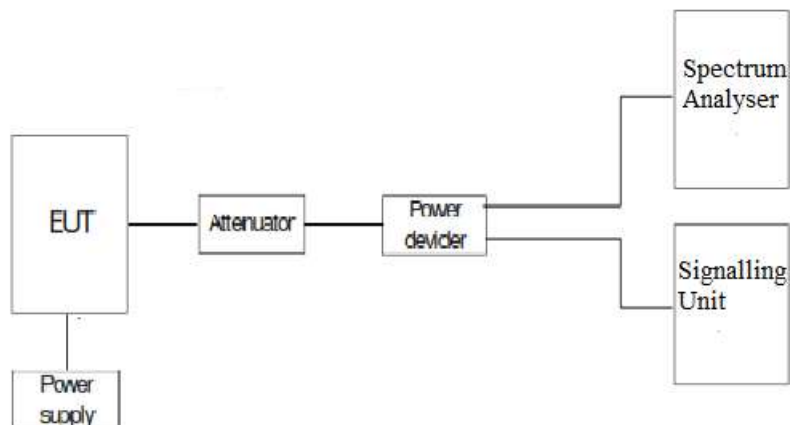
FCC §2.1047.

RSS-132. Clause 5.2: Equipment certified under this standard shall use digital modulation.

Method

For LTE the EUT operates with QPSK and 16QAM modes in which the information is digitized 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).

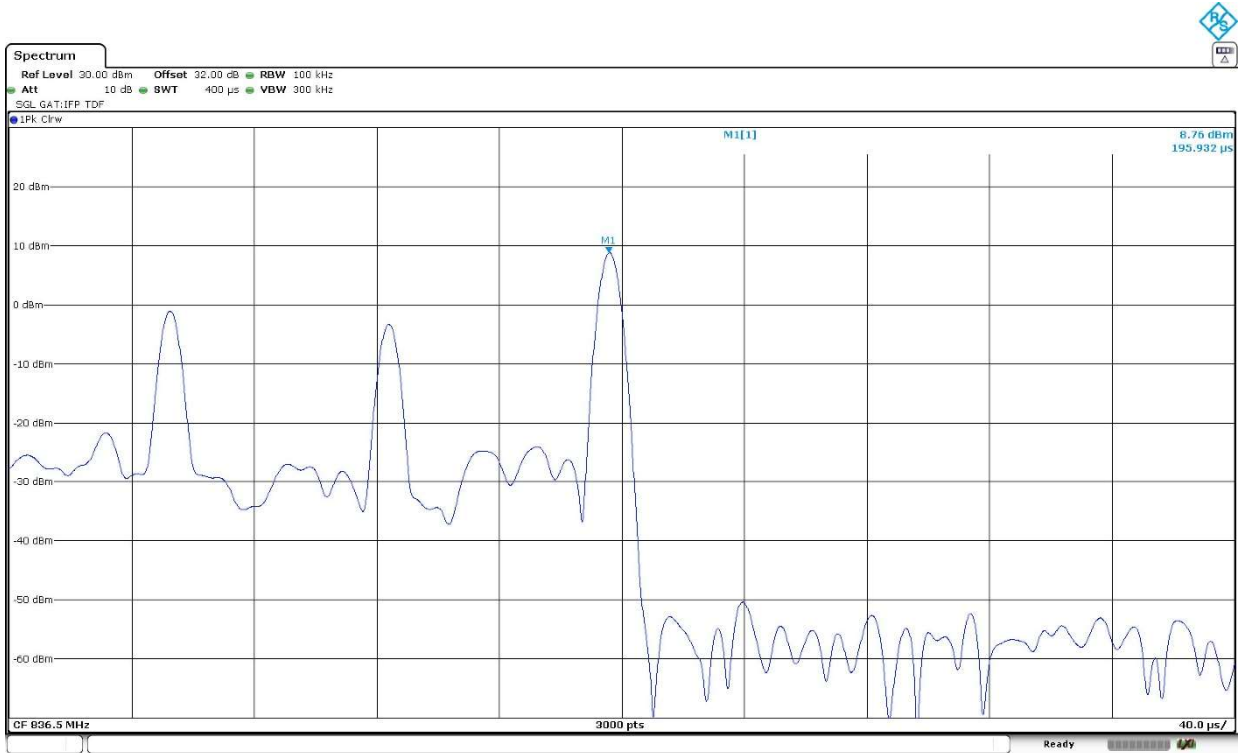
Test Setup



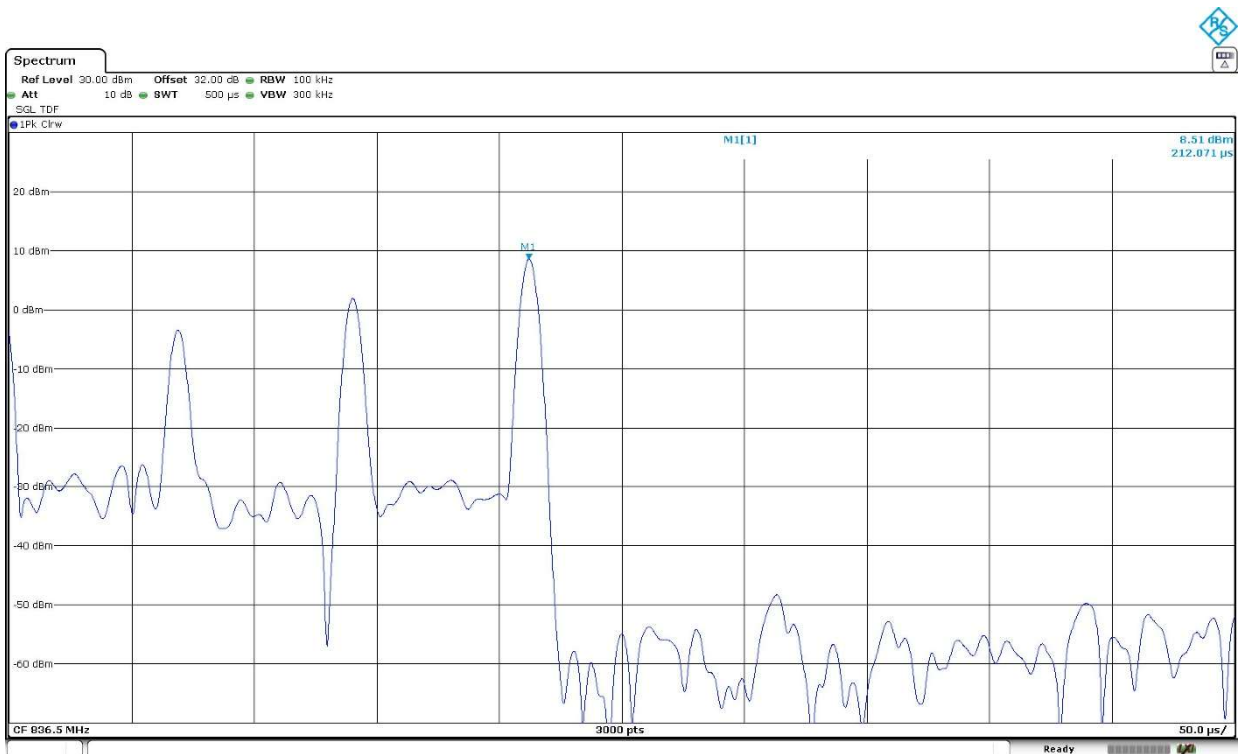
Results

The following plots show the modulation schemes in the EUT.

LTE Cat-M1 Band 26: BW = 1.4 MHz. QPSK.



LTE Cat-M1 Band 26: BW = 1.4 MHz. 16QAM.



Occupied Bandwidth

Limits

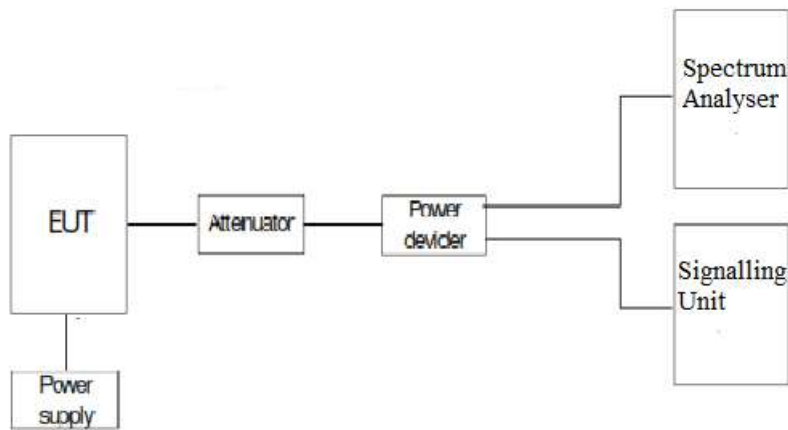
FCC §2.1049. Measurements required: Occupied bandwidth.

RSS-Gen, Clause 6.7.

Method

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

Test Setup



Results

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 Band 26:

LTE Cat-M1 Band 26. BW=1.4 MHz. QPSK. RB Size=6. RB Offset=0. Narrow Band=0.

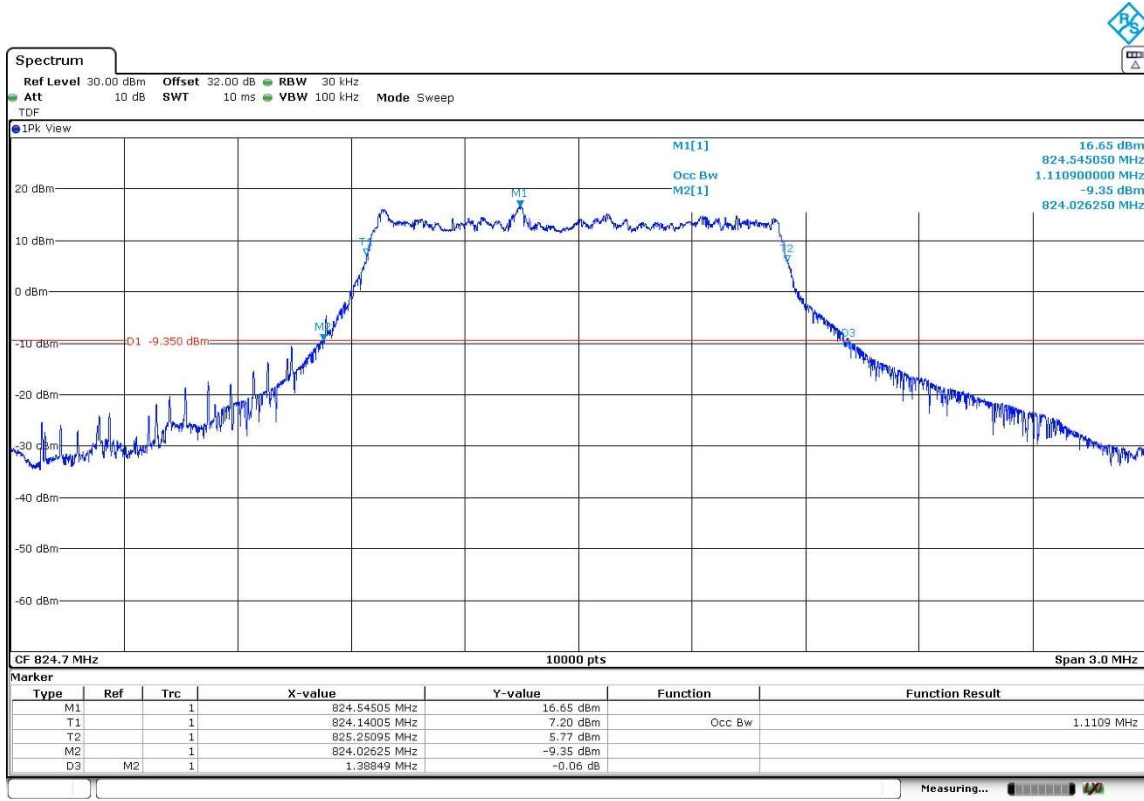
	Low Channel	Middle Channel	High Channel
99% Occupied Bandwidth (MHz)	1.11090	1.10640	1.10790
-26 dBc Bandwidth (MHz)	1.38849	1.43590	1.39068
Measurement uncertainty (kHz)	<±3.75		

LTE Cat-M1 Band 26. BW=1.4 MHz. 16QAM. RB Size=5. RB Offset=0. Narrow Band=0.

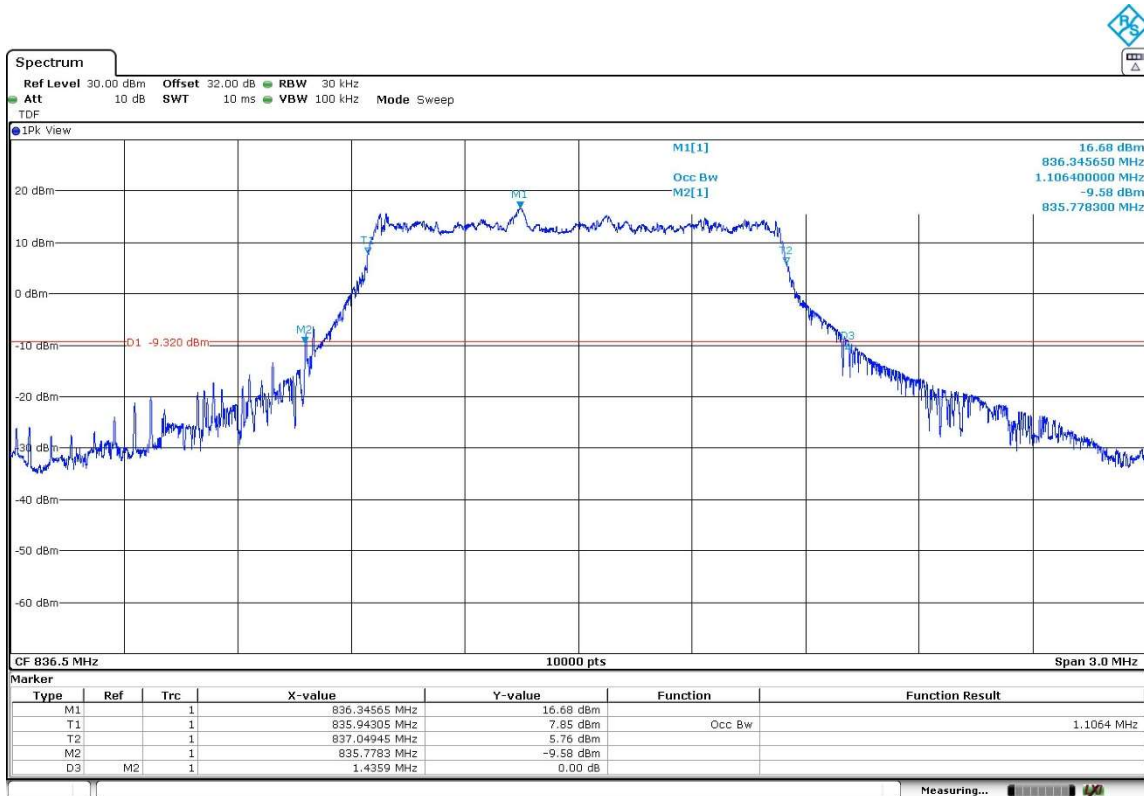
	Low Channel	Middle Channel	High Channel
99% Occupied Bandwidth (MHz)	0.94800	0.94620	0.94860
-26 dBc Bandwidth (MHz)	1.29628	1.30891	1.29364
Measurement uncertainty (kHz)	<±3.75		

LTE Cat-M1 Band 26. BW=1.4 MHz. QPSK. RB Size 6. Offset 0. Narrow Band 0.

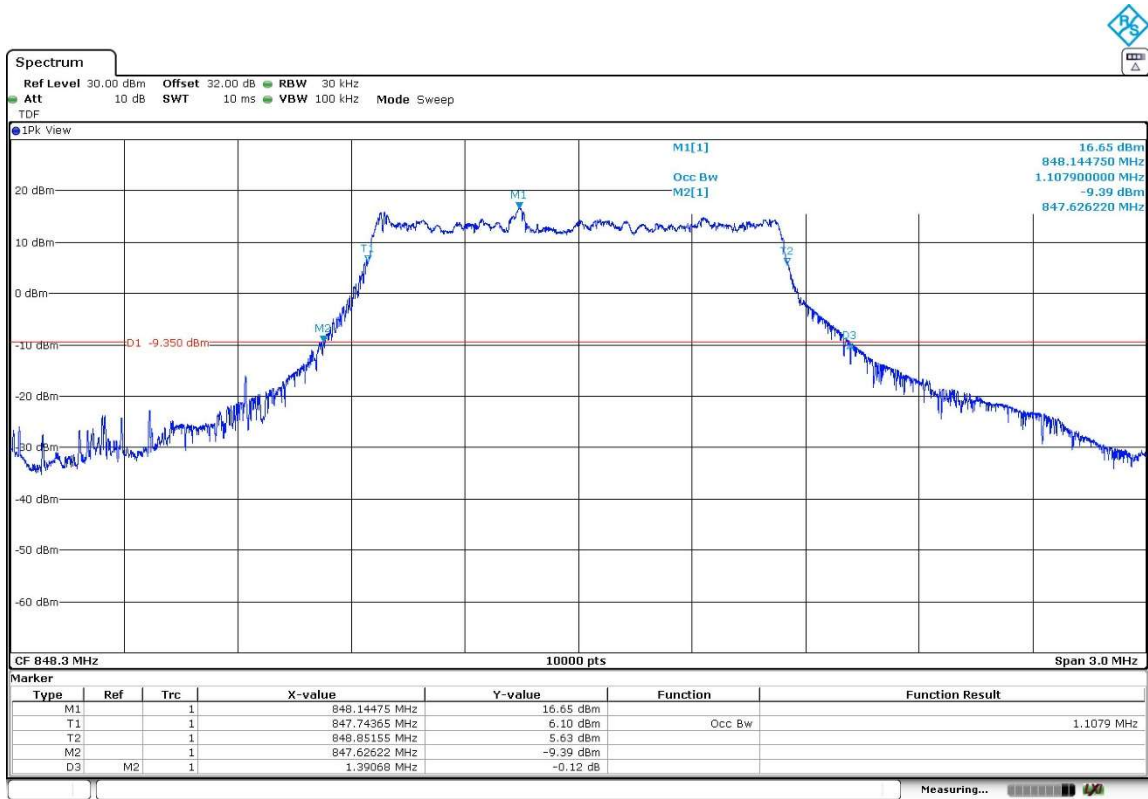
Low Channel:



Middle Channel:

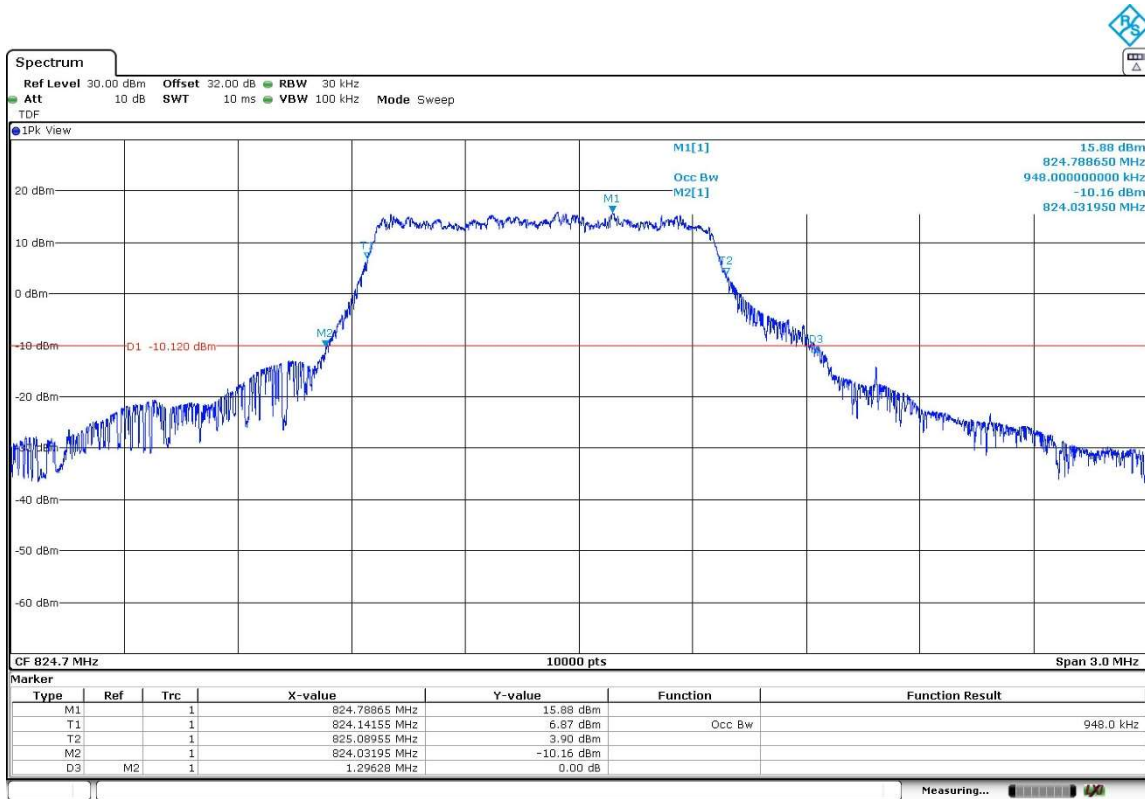


High Channel:



LTE Cat-M1 Band 26. BW=1.4 MHz. 16QAM. RB Size 5. Offset 0. Narrow Band 0.

Low Channel:



Middle Channel:

