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C.I.F. A29507456

ISED CABid: ES1909
Lab. Company Number: 4621A

Test Report No:
75755RRF.003A1

Test Report
USA FCC Part 24
CANADA RSS-133

(*) 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 Nielsens Veg 12, 7052 Trondheim, Norway
Test method requested, standard	USA FCC Part 24 (10-1-21 Edition). CANADA RSS-133 Issue 6, Jan. 2018 Amendment 1. 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 Firmado digitalmente por 53680346W JOSE MANUEL GOMEZ (C:A29507456)
Date of issue	2023-11-30
Report template No.	FDT08_24 (*) "Data provided by the client"

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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 Nº	Description	Model	Serial Nº	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 Nº	Description	Model	Serial Nº	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]	Cable: Attached during test	Cable: Shielded	Cable: Coupled to patient(3)	
	LTE RF		2	☒	☒	☐	
	GPS		2	☐	☐	☐	
Supplementary information to the ports……:	-						
Rated power supply ..... :	Voltage and Frequency		Reference poles: L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☒	☐
	☐	AC:	☐	☐	☐	☒	☐
	☒	DC: 3.0-5.5V					
	☐	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 ..... :	☒	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 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)	2023-06-09

Document history

Report number	Date	Description
75755RRF.003	2023-09-21	First release.
75755RRF.003A1	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 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: Pablo Redondo, Rafael Fernández 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
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 2, 25.

FCC 24 / RSS-133		
Requirement – Test case	**Verdict**	**Remark**
FCC 24.232 / RSS-133 6.4: RF Output Power	P	
FCC 2.1047 / RSS-133 6.2: Modulation characteristics	P	
FCC 24.235 / RSS-133 6.3: Frequency stability	P	
FCC 2.1049: Occupied Bandwidth	P	
FCC 24.238 / RSS-133 6.5: Spurious emissions at antenna terminals	P	
FCC 24.238 / RSS-133 6.5: Spurious emissions at antenna terminals at Block Edges	P	
FCC 24.238 / RSS-133 6.5: Radiated Emissions	P	
Supplementary information and remarks: None.		

Appendix B: LTE Cat NB1 Bands 2, 25.

FCC 24 / RSS-133		
Requirement – Test case	**Verdict**	**Remark**
FCC 24.232 / RSS-133 6.4: RF Output Power	P	
FCC 2.1047 / RSS-133 6.2: Modulation characteristics	P	
FCC 24.235 / RSS-133 6.3: Frequency stability	P	
FCC 2.1049: Occupied Bandwidth	P	
FCC 24.238 / RSS-133 6.5: Spurious emissions at antenna terminals	P	
FCC 24.238 / RSS-133 6.5: Spurious emissions at antenna terminals at Block Edges	P	
FCC 24.238 / RSS-133 6.5: Radiated Emissions	P	
Supplementary information and remarks: None.		

Appendix A: Test results for FCC 24 / RSS-133: LTE Cat-M1 Bands 2, 25

INDEX

TEST CONDITIONS

(*): Declared by the Applicant.

POWER SUPPLY (*):

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

ANTENNA (*):

Band	Gain (dBi)	Type of Antenna
LTE 2	+3.0	SMD
LTE 25	+3.0	SMD

TEST FREQUENCIES:

LTE Cat-M1 Band 2. QPSK and 16QAM:

	Channel per BW=(Frequency, MHz)					
	BW = 1.4 MHz	BW = 3 MHz	BW = 5 MHz	BW = 10 MHz	BW = 15 MHz	BW = 20 MHz
Low	18607 (1850.7)	18615 (1851.5)	18625 (1852.5)	18650 (1855)	18675 (1857.5)	18700 (1860)
Middle	18900 (1880)	18900 (1880)	18900 (1880)	18900 (1880)	18900 (1880)	18900 (1880)
High	19193 (1909.3)	19185 (1908.5)	19175 (1907.5)	19150 (1905)	19125 (1902.5)	19100 (1900)

NOTE: Band 2 is completely included in band 25, so the channels of band 25 were tested to give conformity to the assigned block.

LTE Cat-M1 Band 25. QPSK and 16QAM:

	Channel per BW=(Frequency, MHz)					
	BW = 1.4 MHz	BW = 3 MHz	BW = 5 MHz	BW = 10 MHz	BW = 15 MHz	BW = 20 MHz
Low	26047 (1850.7)	26055 (1851.5)	26065 (1852.5)	26090 (1855)	26115 (1857.5)	26140 (1860)
Middle	26365 (1882.5)	26365 (1882.5)	26365 (1882.5)	26365 (1882.5)	26365 (1882.5)	26365 (1882.5)
High	26683 (1914.3)	26675 (1913.5)	26665 (1912.5)	26640 (1910)	26615 (1907.5)	26590 (1905)

RF Output Power

Limits

FCC § 2.1046 and § 24.232:

Mobile/portable stations are limited to 2 Watts (33 dBm) Effective Isotropic Radiated Power (E.I.R.P.).
The peak-to-average ratio (PAR) of the transmission shall not exceed 13 dB.

RSS-133 Clause 6.4:

Mobile stations and hand-held portables are limited to 2 watts maximum e.i.r.p. The peak-to-average power ratio (PAPR) shall not exceed 13 dB for more than 0.1% of the time using a signal corresponding to the 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 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).

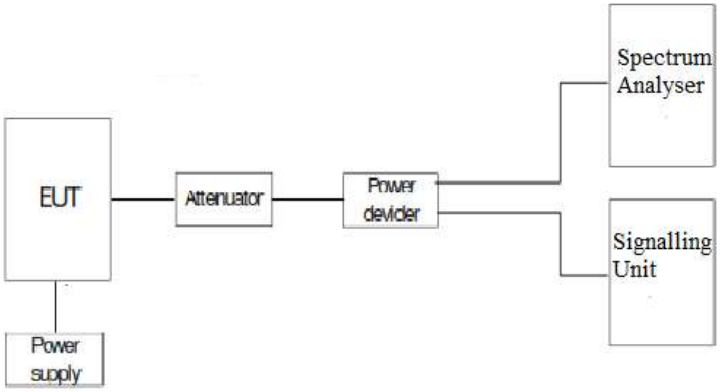
The maximum effective radiated power e.r.p. is calculated from the maximum equivalent isotropically radiated power (e.i.r.p.) by subtracting 2.15 dB:

E.R.P. = E.I.R.P. - 2.15 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 25:

Worst-case of RF Power is BW=10 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)
10	Low 26090	1855	QPSK	1	0	22.47
				1	2	22.41
				1	5	22.40
				3	0	22.46
				3	1	22.49
				3	3	22.49
				6	0	21.49
			16QAM	1	0	22.39
				1	2	22.30
				1	5	22.30
				3	0	22.66
				3	1	22.53
				3	3	22.53
				5	0	21.66
	Middle 26365	1882.5	QPSK	1	0	22.51
				1	2	22.62
				1	5	22.62
				3	0	22.59
				3	1	22.61
				3	3	22.61
				6	0	21.54
			16QAM	1	0	22.68
				1	2	22.73
				1	5	22.74
				3	0	22.80
				3	1	22.84
				3	3	22.84
				5	0	21.63
	High 26640	1910	QPSK	1	0	22.48
				1	2	22.54
				1	5	22.54
				3	0	22.50
				3	1	22.52
				3	3	22.52
				6	0	21.52
			16QAM	1	0	23.13
				1	2	23.14
				1	5	23.14
				3	0	22.41
				3	1	22.42
				3	3	22.42
				5	0	21.74

BW=10 MHz. QPSK modulation:

MAX POWER	QPSK COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG EIRP(dBm)
LOW	22.49	3.0	25.49
MIDDLE	22.62	3.0	25.62
HIGH	22.54	3.0	25.54
MAX:	22.62		25.62

BW=10 MHz. 16QAM:

MAX POWER	16QAM COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG EIRP(dBm)
LOW	22.66	3.0	25.66
MIDDLE	22.84	3.0	25.84
HIGH	23.14	3.0	26.14
MAX:	23.14		26.14

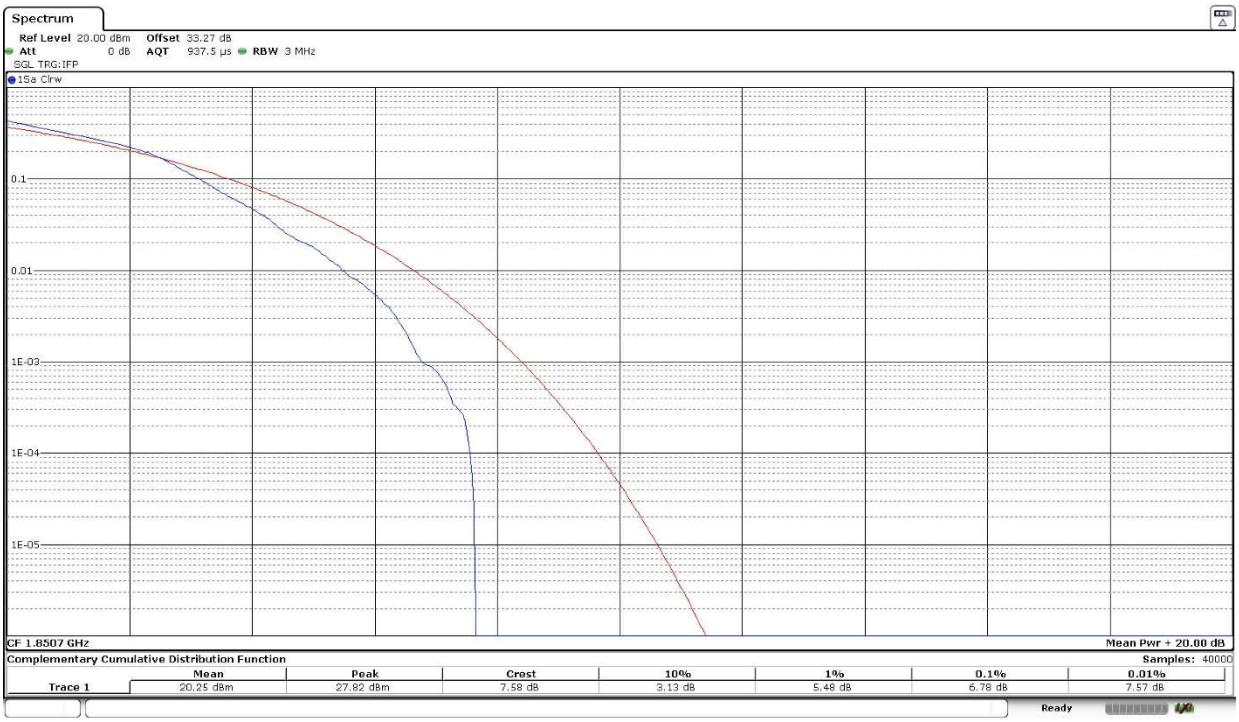
Measurement uncertainty (dB) <±0.941

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

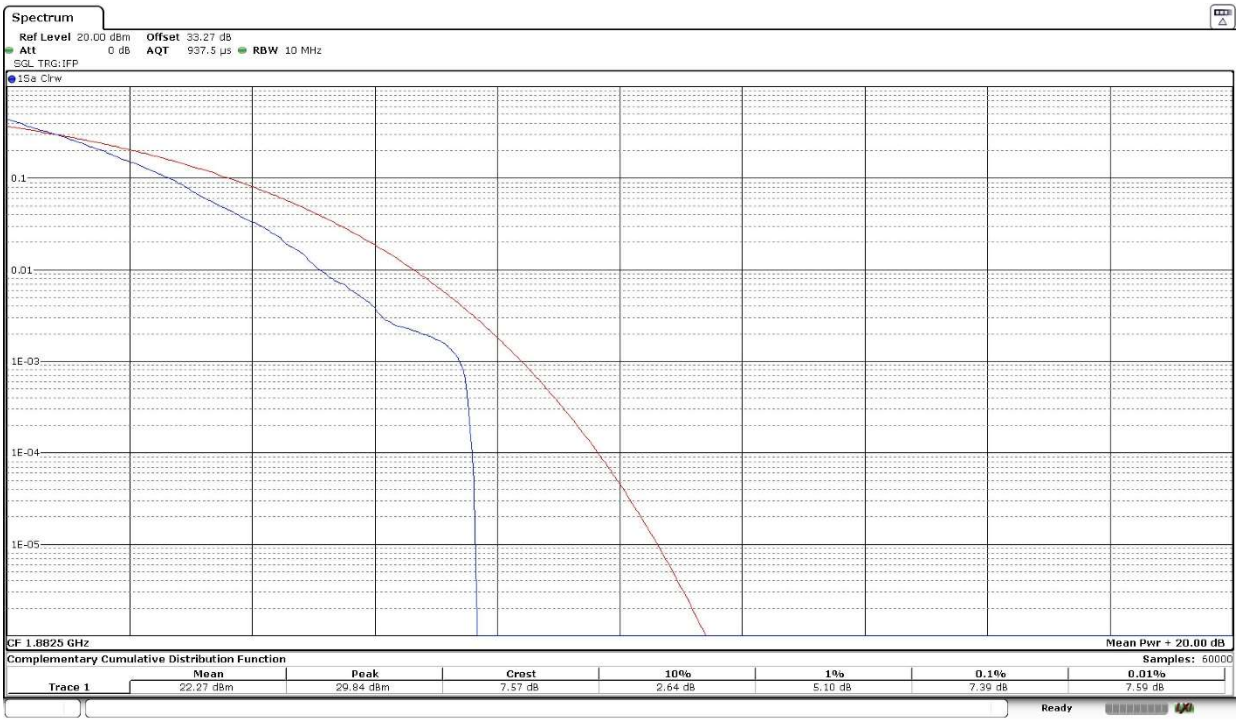
LTE Cat-M1 Band 25:

Worst-case of PAPR is BW=5 MHz, Middle Channel, QPSK, RB Size=1, RB Offset=5, Narrow Band=0.

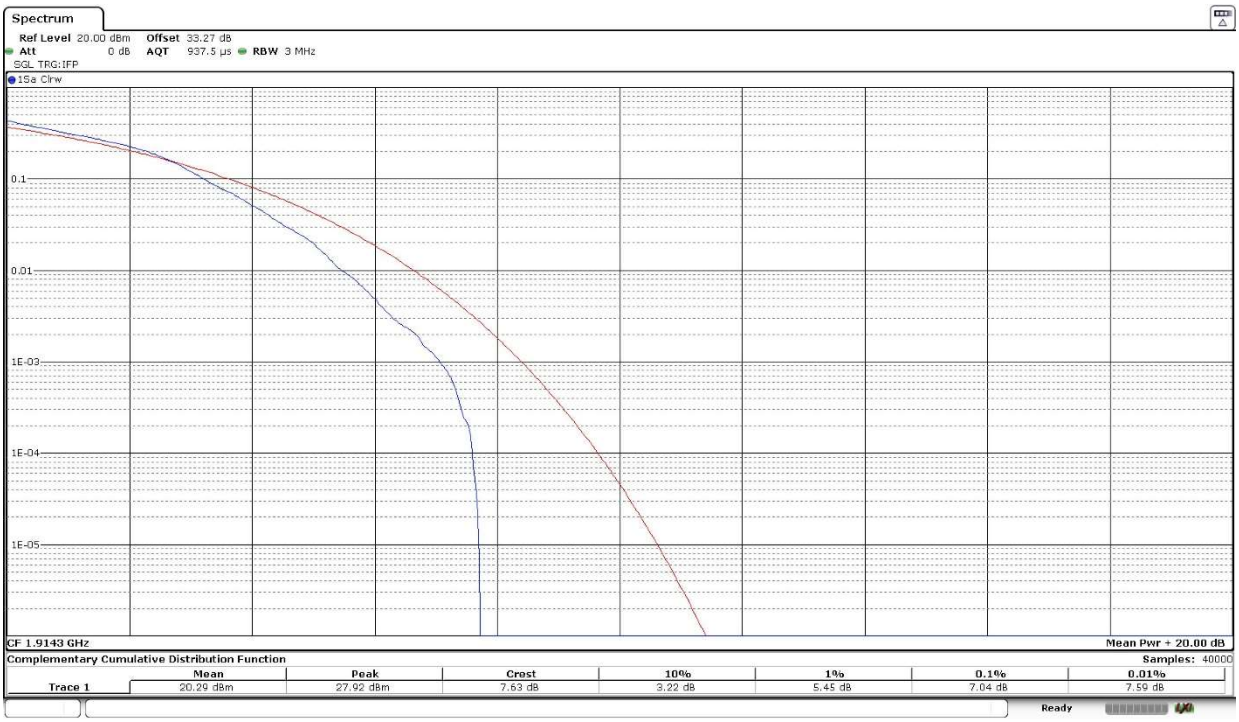
Low Channel:



Middle Channel:



High Channel:



16QAM	Low	Middle	High
PAPR (dB)	6.78	7.39	7.04

Verdict

Pass

Frequency Stability

Limits

FCC §2.1055 and §24.235. The frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block.

RSS-133, Clause 6.3. The carrier frequency shall not depart from the reference frequency in excess of ±2.5 ppm for mobile stations.

Method

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

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

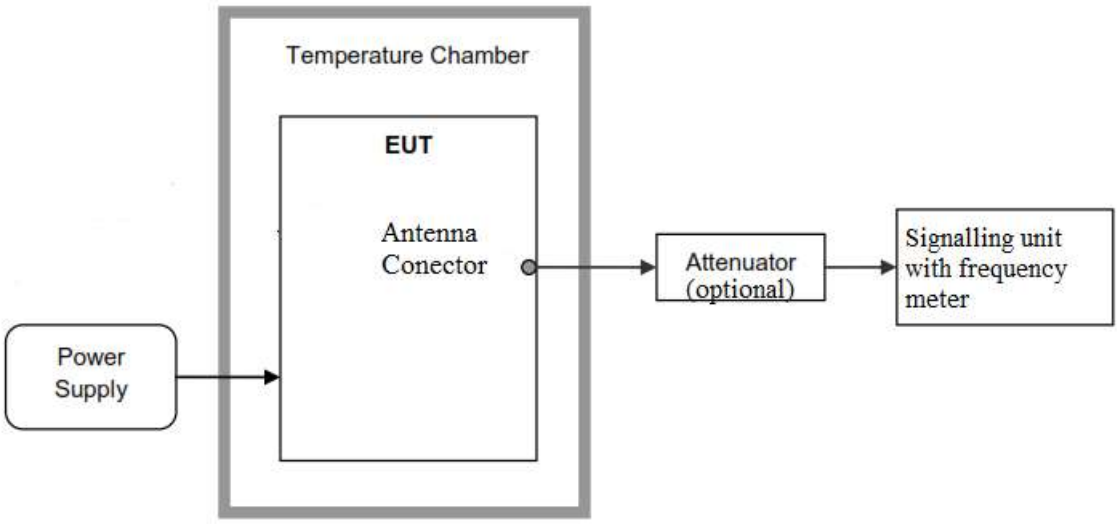
The EUT was set in “Radio Resource Control (RRC) mode” on the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case LTE Cat-M1 mode for conducted power was used for the test.

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.

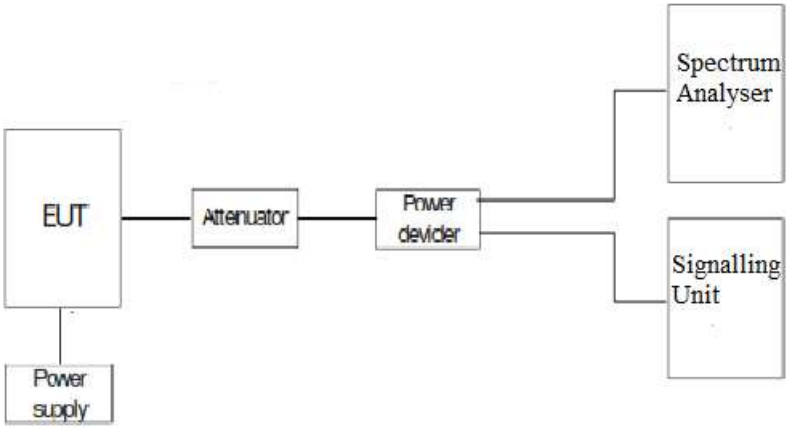
The reference point measurements were made at the RF output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

Test Setup

Frequency tolerance:



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



Results

LTE Cat-M1 Band 25:

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

1. FREQUENCY TOLERANCE:

- **Frequency stability over temperature variations.**

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+85	-3,96	-0,002103586
+80	2,68	0,001423639
+70	-3,41	-0,001811421
+60	-4,88	-0,002592297
+50	5.41	0.002873838
+40	7.22	0.003835325
+30	-1.34	-0.000711819
+20	3.79	0.00201328
+10	4.32	0.002294821
0	8.33	0.004424967
-10	-1.90	-0.001009296
-20	-3.56	-0.001891102
-30	6.82	0.003622842
-40	-1,19	-0,000632138

- **Frequency stability over voltage variations.**

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	-15.65	-0.008313413
Vmin	3	-3,91	-0,002077025

2. REFERENCE FREQUENCY POINTS fL AND fH:

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

*f*L (MHz)	1850.0440
*f*H (MHz)	1914.9748

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

Measurement uncertainty (Hz): <±223.94

Verdict

PASS

Modulation Characteristics

Limits

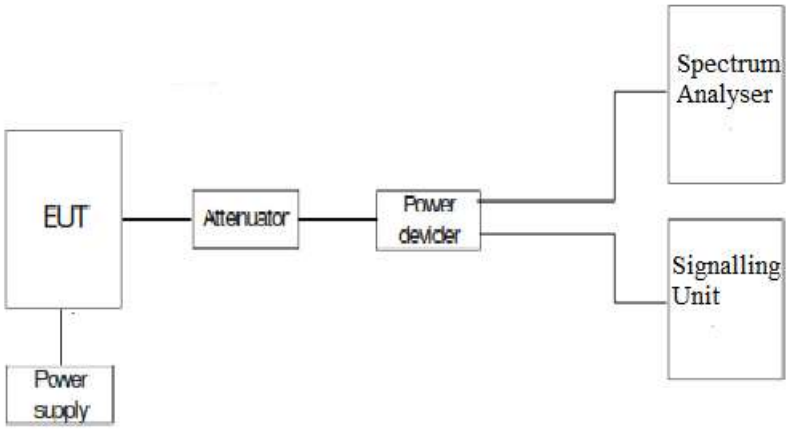
FCC §2.1047.

RSS-133. Clause 6.2. Equipment certified under this standard shall use digital modulation.

Method

For LTE Cat-M1 the EUT operates with QPSK and 16QAM 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).

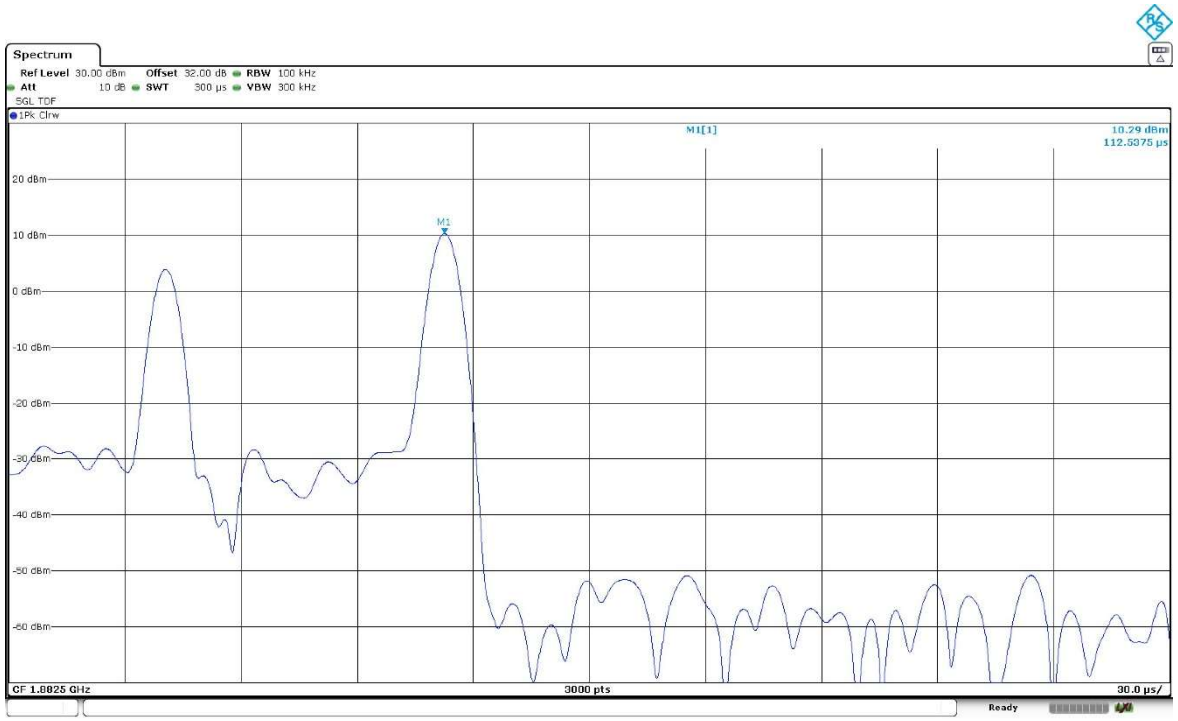
Test Setup



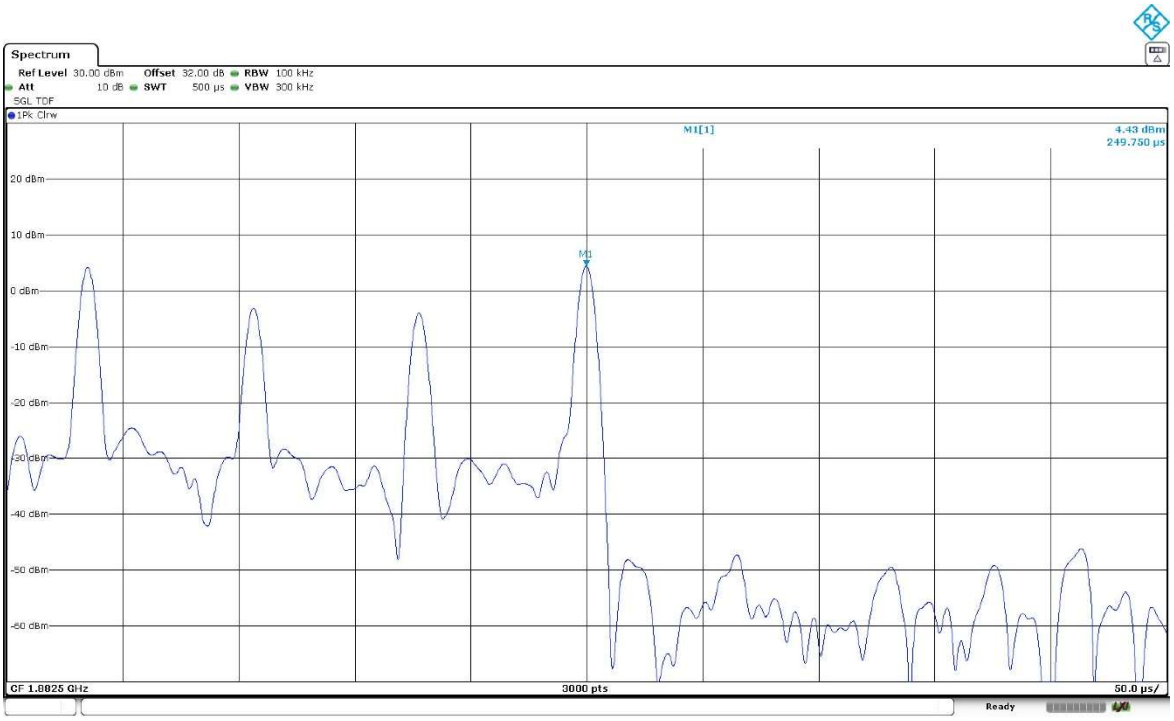
Results

The following plots show the modulation schemes in the EUT.

LTE Cat-M1 Band 25: BW = 1.4 MHz. QPSK.



LTE Cat-M1 Band 25: BW = 1.4 MHz. 16QAM.



Occupied Bandwidth

Limits

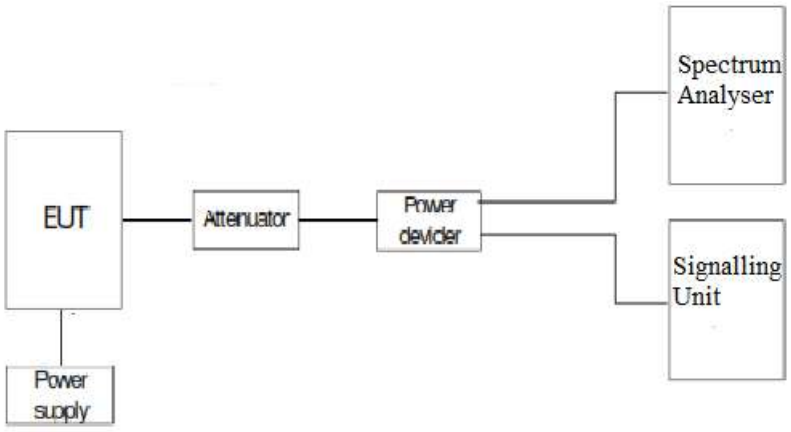
FCC §2.1049. Measurements required: Occupied bandwidth.

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 per modulation is:

LTE Cat-M1 Band 25:

LTE Cat-M1 Band 25. BW=1.4 MHz. QPSK. RB Size=6. RB Offset=0. Narrow Band=0.

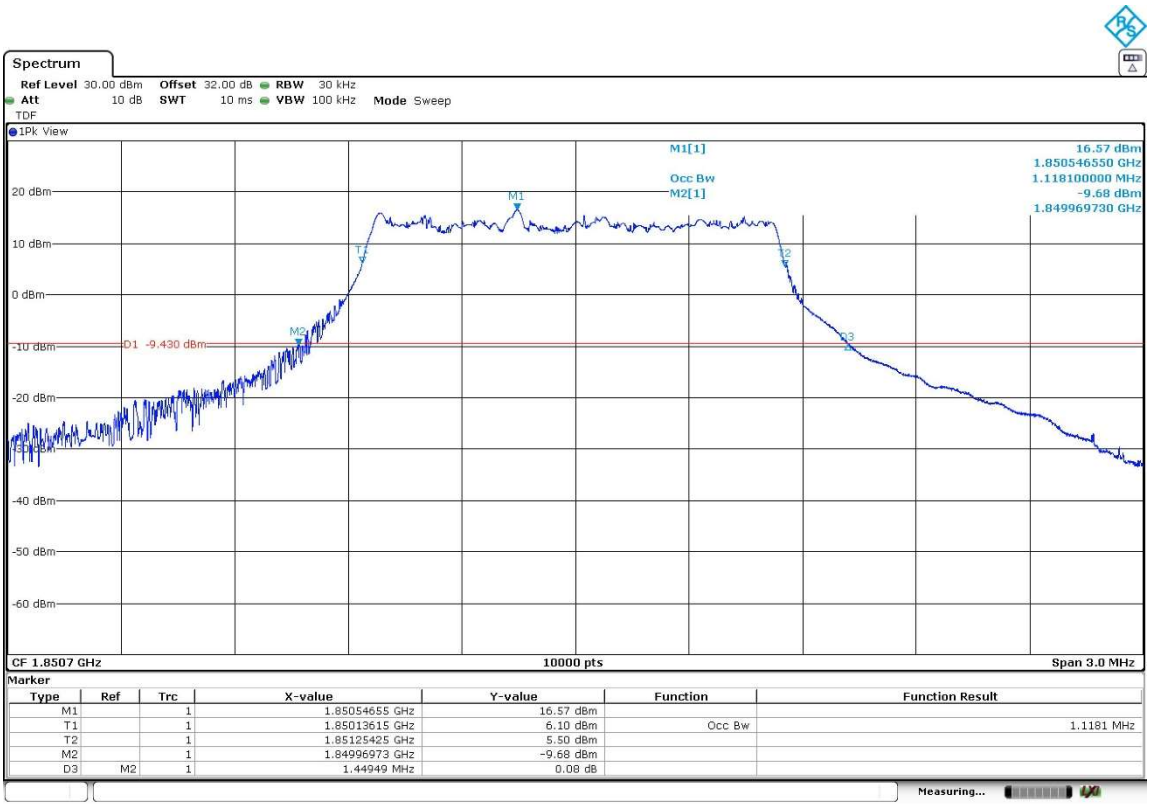
Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	1.11810	1.10940	1.10850
-26 dBc Bandwidth (MHz)	1.44949	1.43317	1.40091
Measurement uncertainty (kHz)	<±5.20		

LTE Cat-M1 Band 25. BW=1.4 MHz. 16QAM. RB Size=5. RB Offset=0. Narrow Band=0.

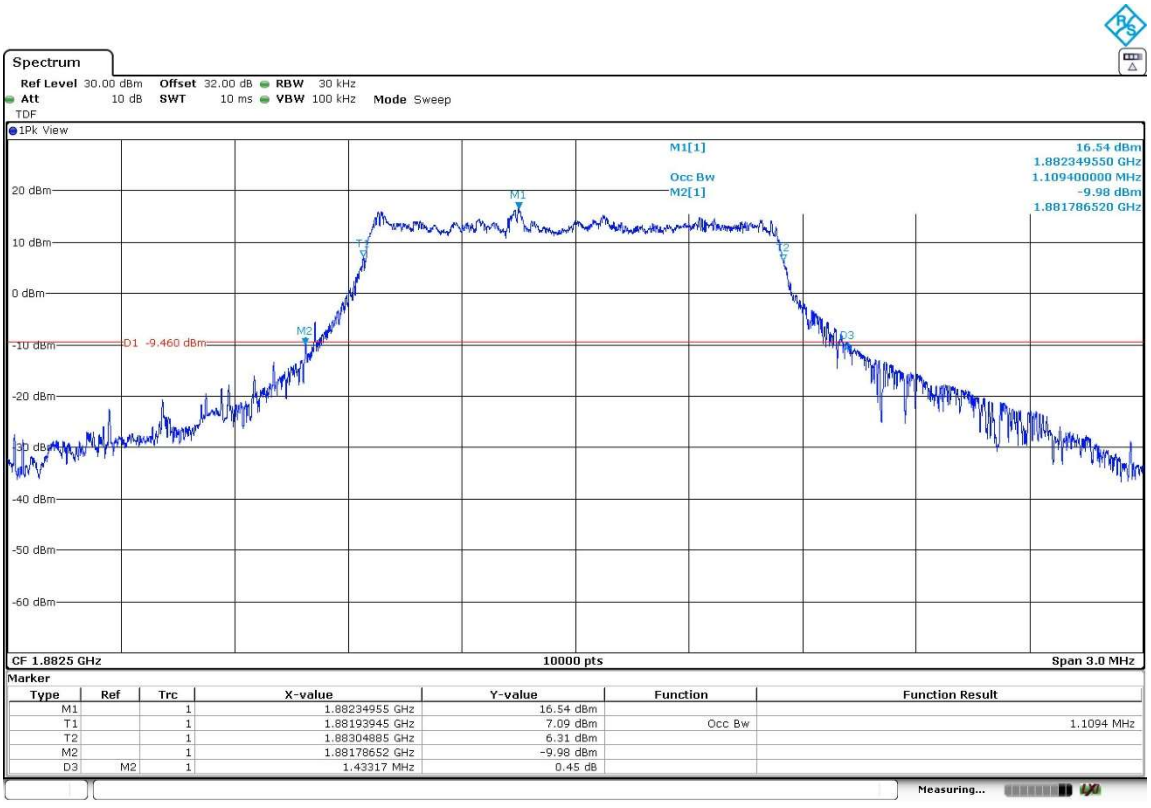
Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	0.94920	0.95130	0.95100
-26 dBc Bandwidth (MHz)	1.31401	1.28509	1.30171
Measurement uncertainty (kHz)	<±5.20		

LTE Cat-M1 Band 25. BW=1.4 MHz. QPSK. RB Size=6. RB Offset=0. Narrow Band=0.

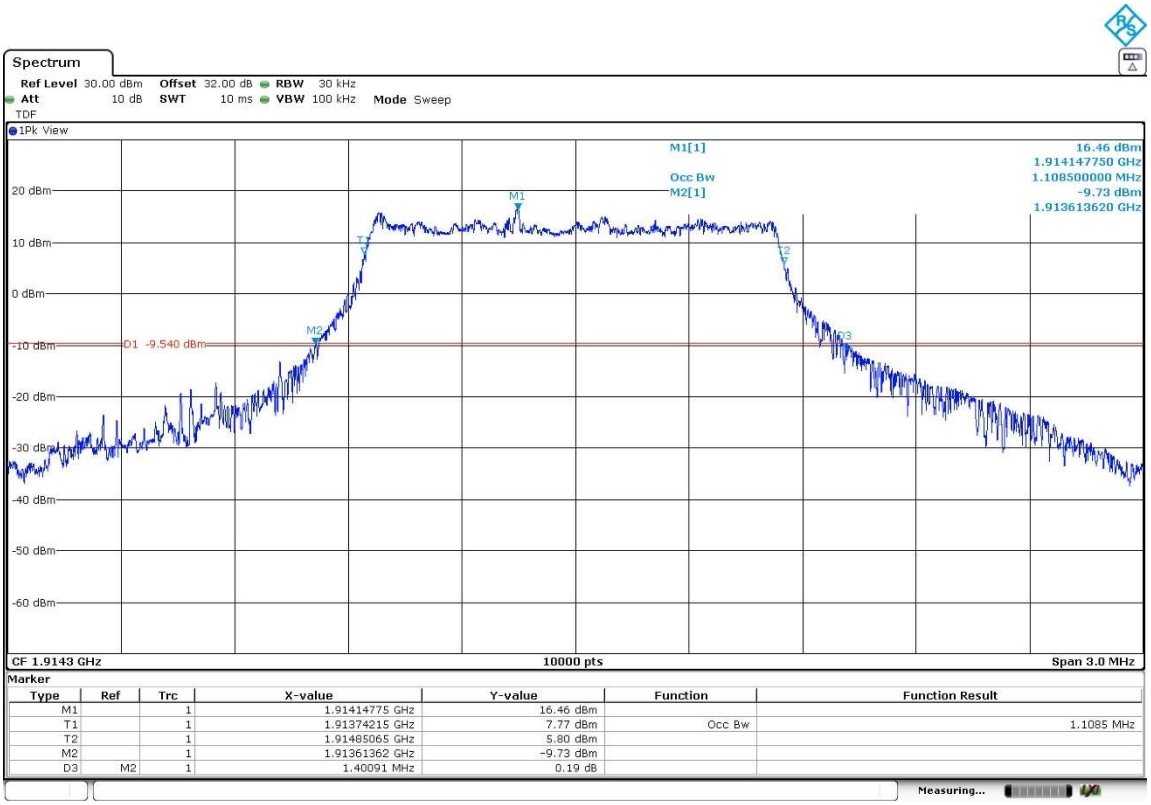
Low Channel:



Middle Channel:

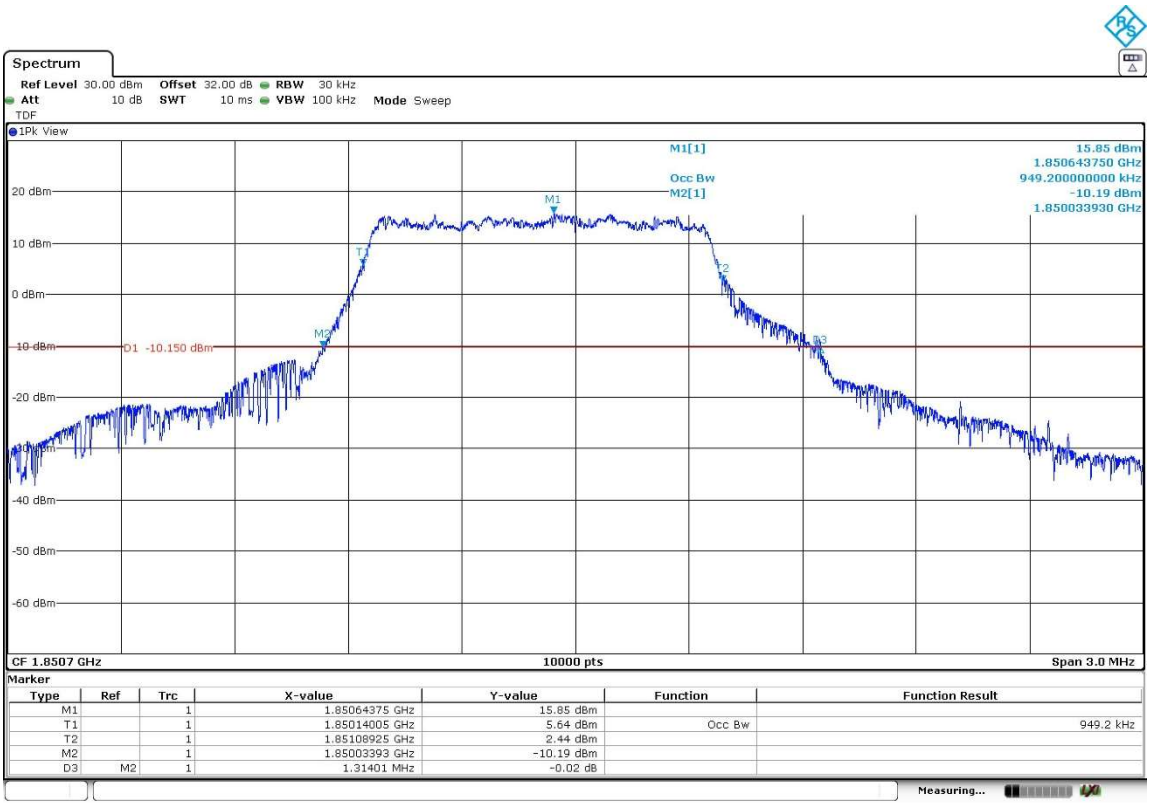


High Channel:

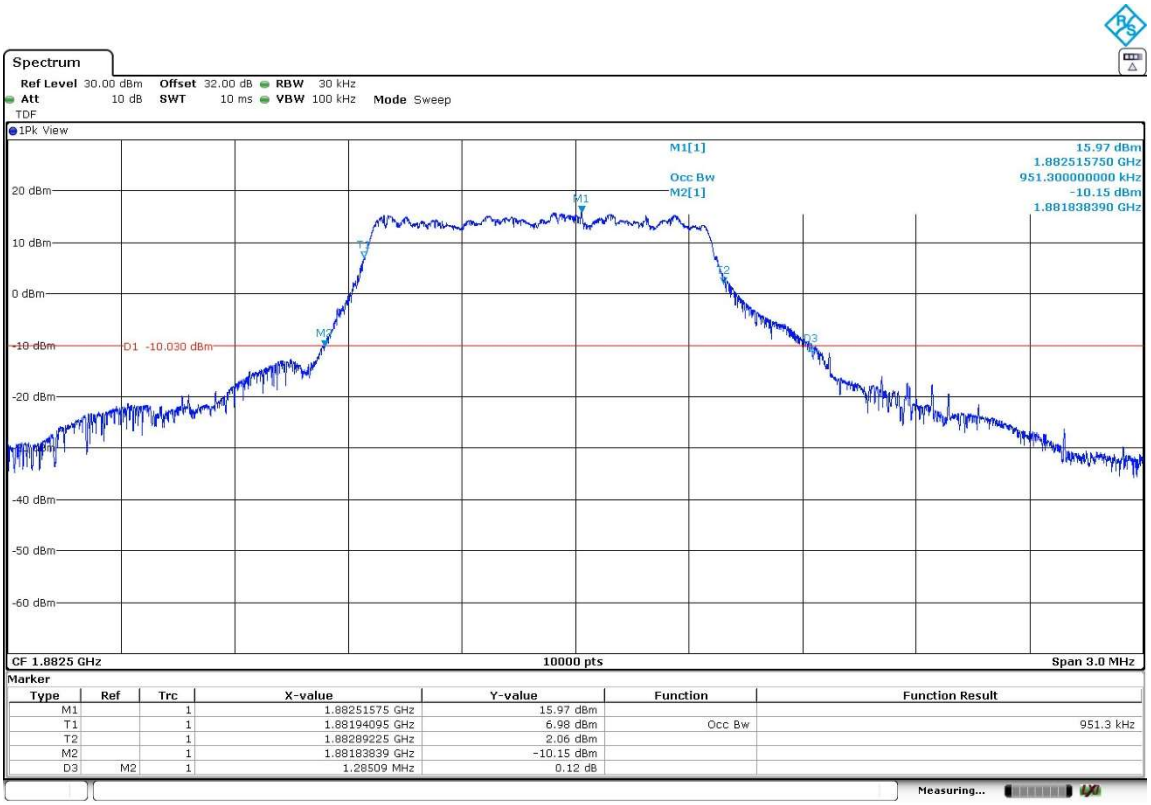


LTE Cat-M1 Band 25. BW=1.4 MHz. 16QAM. RB Size=5. RB Offset=0. Narrow Band=0.

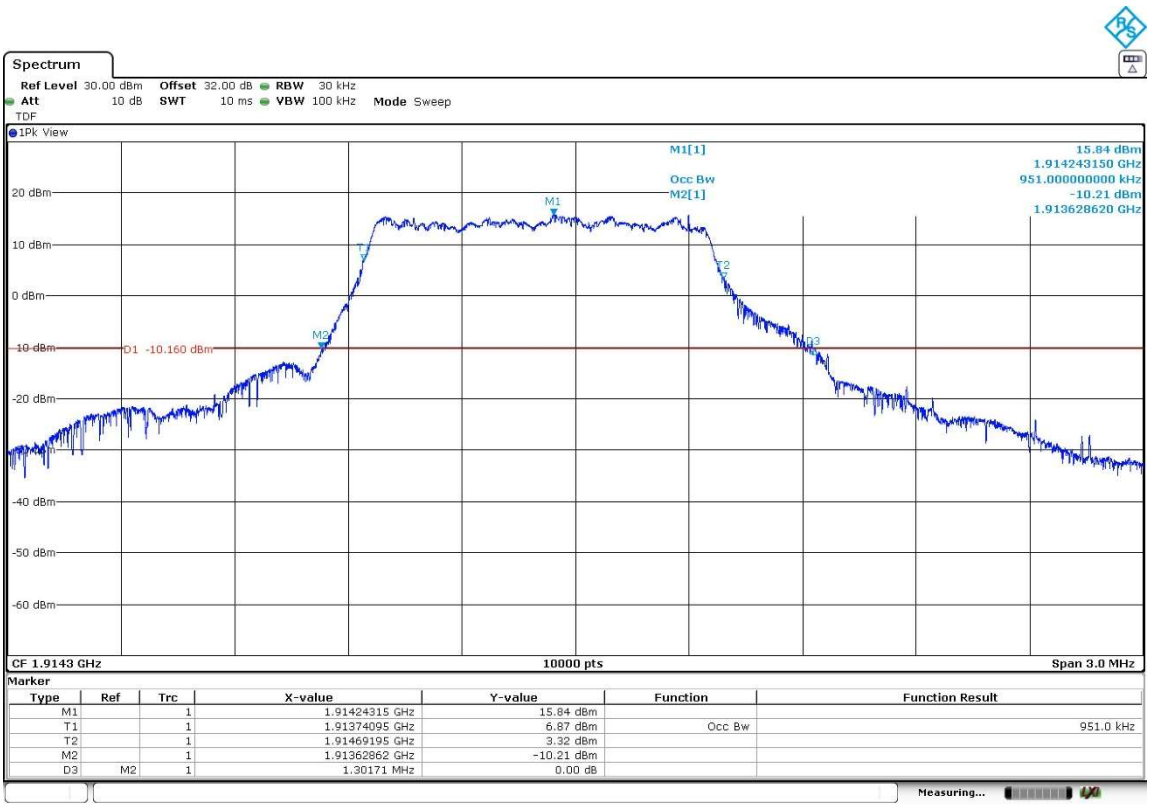
Low Channel:



Middle Channel:



High Channel:



Spurious Emissions at Antenna Terminals

Limits

FCC §2.1051 and §24.238. RSS-133, Clause 6.5.

> The power of emissions shall be attenuated below the transmitter power (P) by a factor of at least 43 + 10 log (P) dB. P in watts.
>
> Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 1 MHz or greater.

At Po transmitting power, the specified minimum attenuation becomes 43+10 log (Po), and the level in dBm relative to Po becomes:

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

Method

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

The spectrum was investigated from 9 kHz to 20 GHz.

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