DEKRA Testing and Certification, S.A.U.
Parque Tecnológico de Andalucía,
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C.I.F. A29507456

ISED CABid: ES1909
Lab. Company Number: 4621A

Test Report No:
77535RRF.002A1

Test Report
USA FCC Part 24
CANADA RSS-133

(*) Identification of item tested	nRF91
(*) Trademark	nRF91
(*) Model and /or type reference	nRF9151
Other identification of the product	FCC ID: 2ANPO00nRF9151 IC: 24529-NRF9151
(*) Features	LTE Cat-M1, LTE NB1&NB2 HW version: nRF9151 LACA AA SW version: mfw_nrf91x1_2.0.0
Applicant	NORDIC SEMICONDUCTOR ASA Otto Nielsens Veg 12, 7052 Trondheim, Norway
Test method requested, standard	USA FCC Part 24 (10-1-22 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	2024-04-04
Report template No.	FDT08_24 (*) "Data provided by the client"

ENAC ENSAYO ISO 17025 Nº51 / LE147

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Competences and guarantees

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

DEKRA Testing and Certification 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.

In order to assure the traceability to other national and international laboratories, DEKRA Testing and Certification has a calibration and maintenance program for its measurement equipment.

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General conditions

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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 nRF9151 DK is a Development Kit that has nRF9151 IOT Module and GPS. The nRF9151 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.

Id	Control Number	Description	Model	HW Version	Serial Nº	Date of Reception	Application
S/01	77535C/025_.1	nRF91	nRF9151	nRF9151 LACA CB0	1051231716	2024-01-08	Element Under Test
S/01	77535C/022_.1	SMA Cable	-	-	-	2024-01-08	Auxiliary Element
S/01	77535C/013_.1	USB Cable	-	-	-	2024-01-08	Auxiliary Element
S/02	77535C/026_.1	nRF91	nRF9151	nRF9151 LACA CB0	1051261483	2024-01-08	Element Under Test
S/02	77535C/012_.1	USB Cable	-	-	-	2023-12-15	Auxiliary Element
S/03	77535C/027_.1	nRF91	nRF9151	nRF9151 LACA CB0	1051275581	2024-01-08	Element Under Test
S/03	77535C/023_.1	SMA Cable	-	-	-	2024-01-08	Auxiliary Element
S/03	77535C/015_.1	USB Cable	-	-	-	2024-01-08	Auxiliary Element
S/04	77535C/036_.1	nRF91	nRF9151	nRF9151 LACA AA	1051266193	2024-01-29	Element Under Test
S/04	77535C/015_.1	USB Cable	-	-	-	2024-01-08	Auxiliary Element

Notes referenced to samples during the project:

Id	Type
S/01	Conducted tests.
S/02	Radiated tests.
S/03	Conducted tests: but the RF Output Power tests.
S/04	Radiated test. Testing only in B25 NB-IoT.

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	☐	☐	☐
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, nominal 3.8V					
	☐	DC:					
Rated Power..... :	1W						
Clock frequencies..... :	32kHz, 32MHz						
Other parameters ..... :	Temperature range: -40C..+85C						
Software version..... :	mfw_nrf91x1_2.0.0						
Hardware version ..... :	nRF9151 LACA AA						
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)	2024-01-22
Date (finish)	2024-02-22

Document history

Report number	Date	Description
77535RRF.002	2024-03-21	First release.
77535RRF.002A1	2024-04-04	Second release. Typos corrected about NB1 and NB2 references. This report replaces and cancels 77535RRF.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: Francisco López, Sergio Carrasco, Rafael Fernández, Ireneo Bibang, Pablo Redondo, Carmen Vázquez.

Used instrumentation:

Control No.	Equipment	Model	Manufacturer	Next Calibration
7760	Digital Multimeter	175	FLUKE	2024-11
6667	Wideband Radio Communication Tester	CMW500	ROHDE AND SCHWARZ	2024-06
6666	EMI TEST RECEIVER 2Hz-44GHz	ESW44	ROHDE AND SCHWARZ	2024-03
8002	TEMPERATURE CHAMBER MK56 BINDER	MK 56	BINDER	2024-04
6157	Signal and Spectrum Analyzer 10 Hz - 40 GHz	FSV40	ROHDE AND SCHWARZ	2025-01
6794	Shielded Room	S101	ETS LINDGREN	N/A
9227	Wideband Radio Communication Tester	CMW500	ROHDE AND SCHWARZ	2024-07
6254	Attenuator 6 dB 2W DC-26.5 GHz,	TWSMAG2	TECHNIWAVE	2024-03
2215	Power Divider DC-25 GHz	5333-104	PICOSECOND PULSE LABS	2024-07
6791	SEMIANECHOIC ABSORBER LINED	FACT 3 200 STP	ETS LINDGREN	N/A
6792	SHIELDED ROOM	S101	ETS LINDGREN	N/A
6143	Biconical/Log Antenna 30 MHz - 6 GHz	3142E	ETS LINDGREN	2027-01
6021	Attenuator 3 dB, 2W, DC-6GHz	50HN-03	JFW	2025-02
6496	HORN ANTENNA 1-18GHz	BBHA 9120 D	SCHWARZBECK	2026-12
3783	PRE-AMPLIFIER G>30dB 1GHz-18GHz	BLMA 0118-3A	BONN ELEKTRONIK	2025-02
8856	Pre-Amplifier G>30dB 17-40GHz	BLMA 1840-4A	BONN ELEKTRONIK	2025-01
4657	Horn Antenna 18-40 GHz	BBHA 9170	SCHWARZBECK MESS-ELEKTRONIK	2026-06
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 NB2 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

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TEST CONDITIONS

(*): Declared by the Applicant.

POWER SUPPLY (*):

Vnormal: 3.8 Vdc.
Vminimum: 3 Vdc
Vmaximum: 5.5 Vdc

Type of Power Supply: Internal DC.

ANTENNA (*):

Band	Gain (dBi)	Type of Antenna
LTE Cat-M1 2	+3.0	SMD
LTE Cat-M1 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: LTE Cat-M1 Band 2 is completely included in the LTE Cat-M1 Band 25, so the channels of LTE Cat-M1 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).

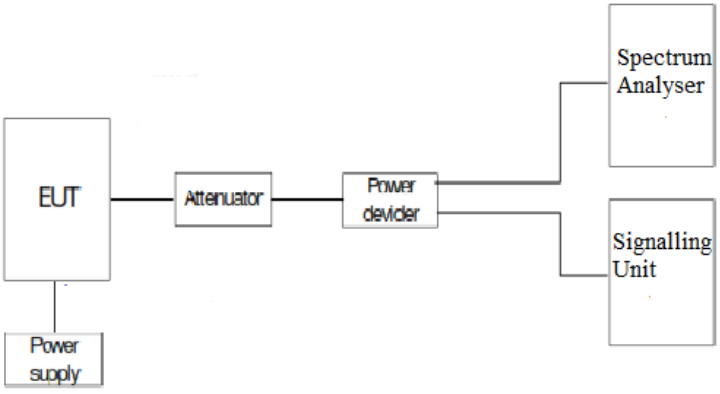
The maximum effective radiated power e.r.p. is calculated from the maximum equivalent isotropically radiated power (e.i.r.p.) by subtracting 2.15 dB:

E.R.P. = E.I.R.P. - 2.15 dB

Test Setup

1. CONDUCTED AVERAGE POWER:

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



Results

1. CONDUCTED AVERAGE POWER:

LTE Cat-M1 Band 25:

Worst-case of RF Power is BW=15 MHz, Middle Channel, 16QAM, RB Size=5, RB Offset=0, Narrowband=0.

BANDWIDTH (MHz)	CHANNEL	FREQUENCY (MHz)	MODULATION	RB SIZE	RB OFFSET	AVERAGE POWER (dBm)
15	Low 26115	1857.5	QPSK	1	0	22.48
				1	2	22.52
				1	5	22.5
				3	0	22.57
				3	1	22.57
				3	3	22.56
				6	0	22.62
			16QAM	1	0	22.51
				1	2	22.52
				1	5	22.53
				3	0	22.65
				3	1	22.67
				3	3	22.67
				5	0	22.72
	Middle 26365	1882.5	QPSK	1	0	22.64
				1	2	22.59
				1	5	22.59
				3	0	22.6
				3	1	22.74
				3	3	22.71
				6	0	22.79
			16QAM	1	0	22.5
				1	2	22.52
				1	5	22.57
				3	0	22.62
				3	1	22.75
				3	3	22.74
				5	0	22.79
	High 26615	1907.5	QPSK	1	0	22.66
				1	2	22.56
				1	5	22.69
				3	0	22.68
				3	1	22.69
				3	3	22.69
				6	0	22.74
			16QAM	1	0	22.58
				1	2	22.54
				1	5	22.52
				3	0	22.67
				3	1	22.7
				3	3	22.7
				5	0	22.77

BW=15 MHz. QPSK:

MAX POWER	QPSK COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG EIRP(dBm)	RAD. POWER AVG ERP(dBm)
LOW	22.62	3	25.62	23.47
MIDDLE	22.79	3	25.79	23.64
HIGH	22.74	3	25.74	23.59
MAX:	22.79		25.79	23.64

BW=15 MHz. 16QAM:

MAX POWER	16QAM COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG EIRP(dBm)	RAD. POWER AVG ERP(dBm)
LOW	22.72	3	25.72	23.57
MIDDLE	22.79	3	25.79	23.64
HIGH	22.77	3	25.77	23.62
MAX:	22.79		25.79	23.64

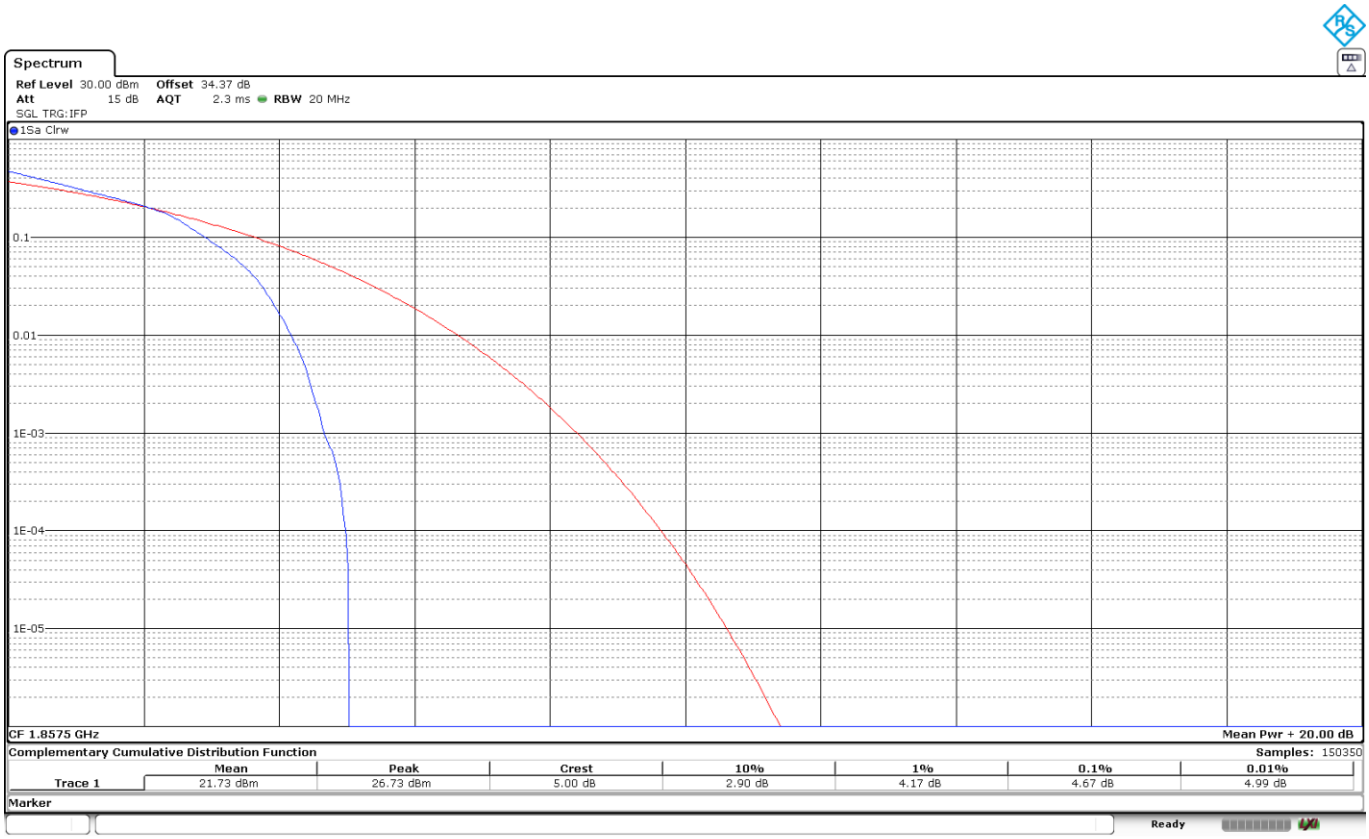
Measurement uncertainty (dB) <±0.941

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

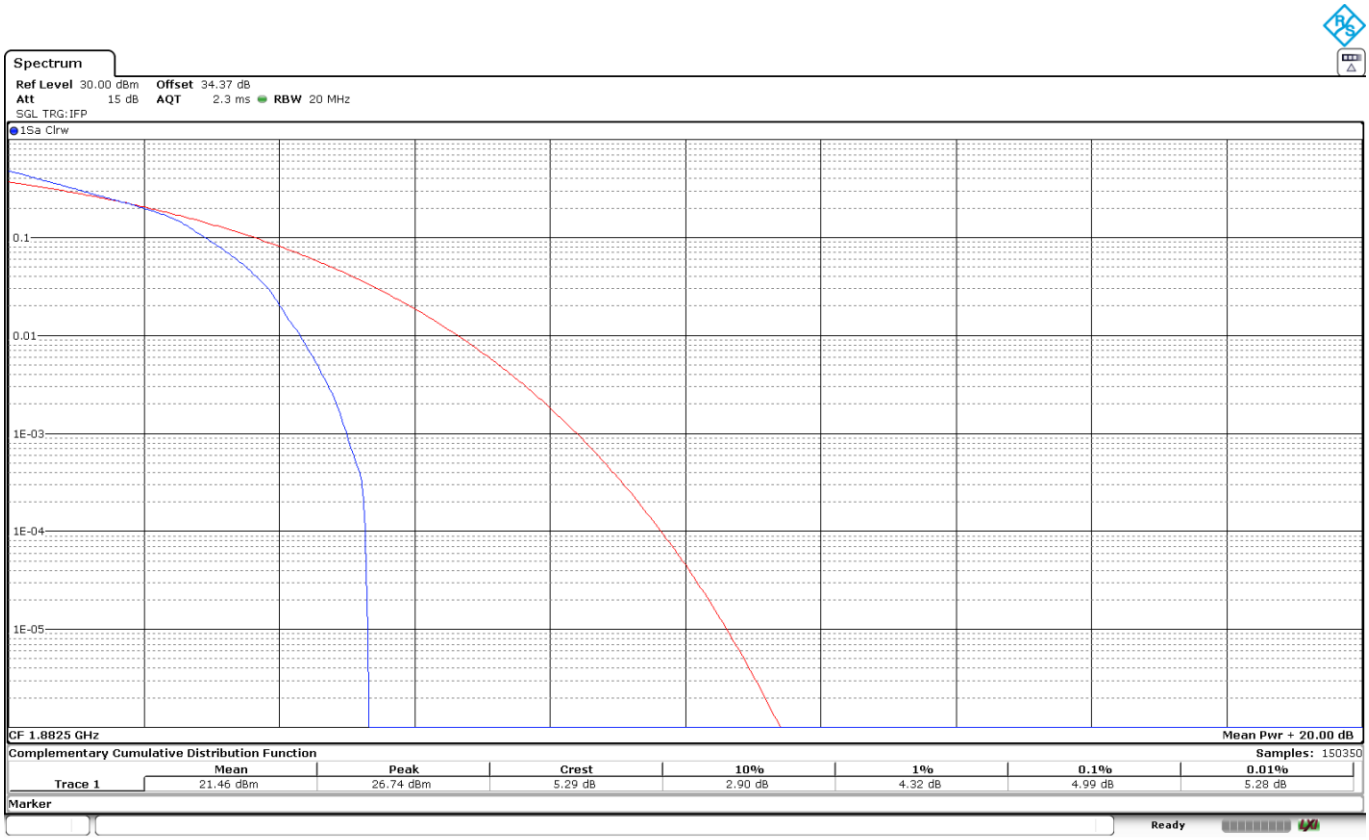
LTE Cat-M1 Band 25:

Worst-case of PAPR is BW=15 MHz, Middle Channel, 16QAM, RB Size=3, RB Offset=3, Narrowband=11.

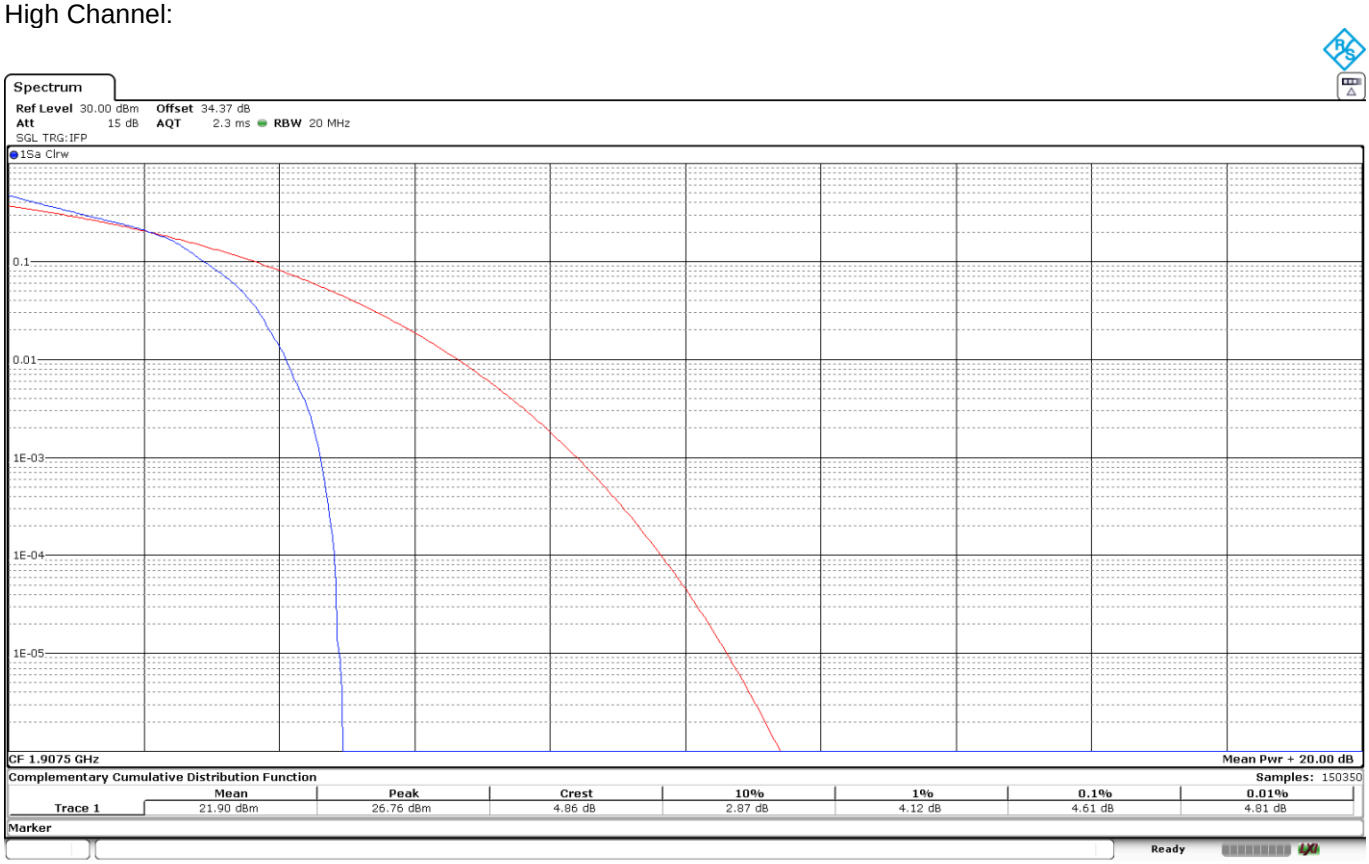
Low Channel:



Middle Channel:



High Channel:



16QAM	Low	Middle	High
PAPR (dB)	4.67	4.99	4.61

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 -40ºC to +85ºC. The EUT was placed inside a climatic chamber and the temperature was raised hourly in 10ºC steps from -40ºC up to +85ºC.
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.

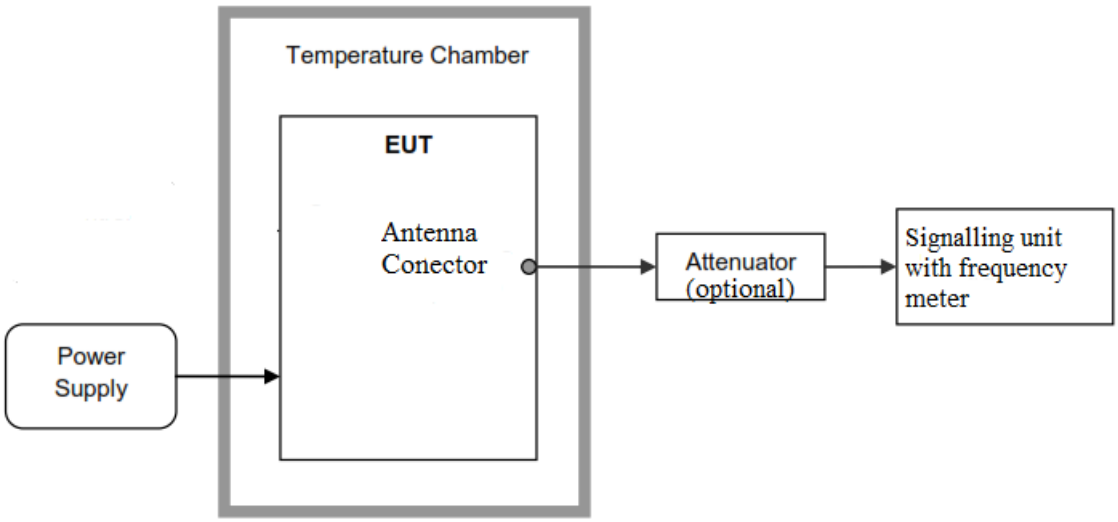
The EUT was set in “Radio Resource Control (RRC) mode” on the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case LTE Cat-M1 mode for conducted power was used for the test.

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 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.

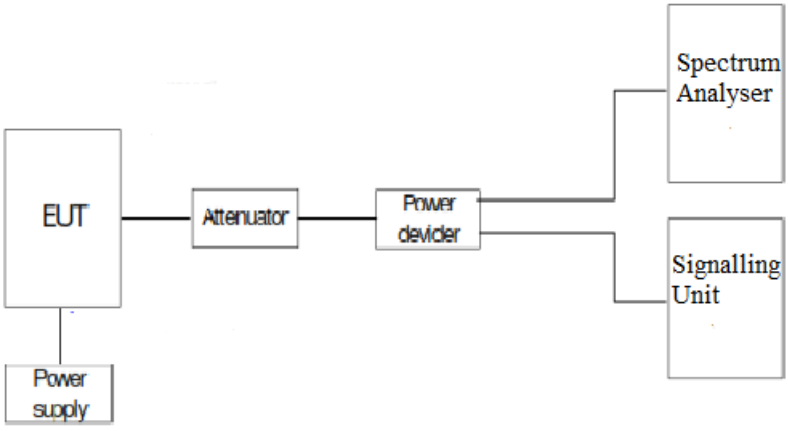
The reference point measurements were made at the RF output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

Test Setup

Frequency tolerance:



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



Results

LTE Cat-M1 Band 25:

The worst case modulation in terms of Frequency Stability is BW=1.4 MHz, QPSK, RB Size=1, RB Offset=0.

1. FREQUENCY TOLERANCE:

- **Frequency stability over temperature variations.**

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+85	-1.13	-0.000600266
+80	3.39	0.001800797
+70	-1.57	-0.000833997
+60	5.12	0.002719788
+50	5.58	0.002964143
+40	1.43	0.000759628
+30	-4.29	-0.002278884
+20	6.82	0.003622842
+10	1.39	0.00073838
0	6.14	0.00326162
-10	0.06	3.18725E-05
-20	0.47	0.000249668
-30	1.55	0.000823373
-40	-5.11	-0.002714475

- **Frequency stability over voltage variations.**

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	1.53	0.000812749
Vmin	3	1.47	0.000780876

2. REFERENCE FREQUENCY POINTS fL AND fH:

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

*f*L (MHz)	1850.0035
*f*H (MHz)	1914.9785

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

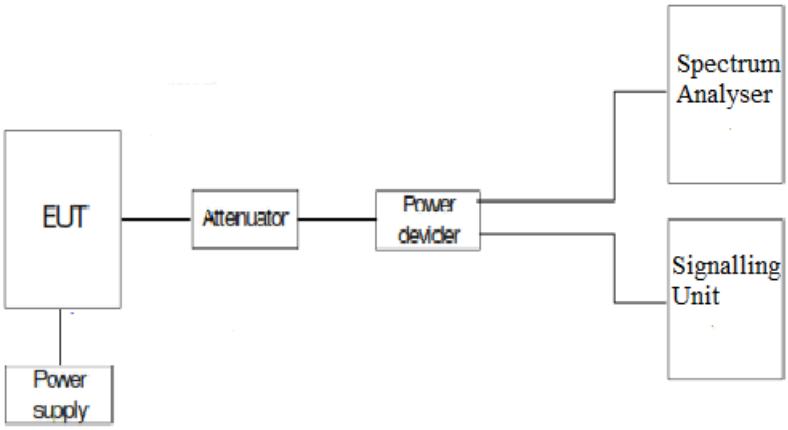
FCC §2.1047.

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).

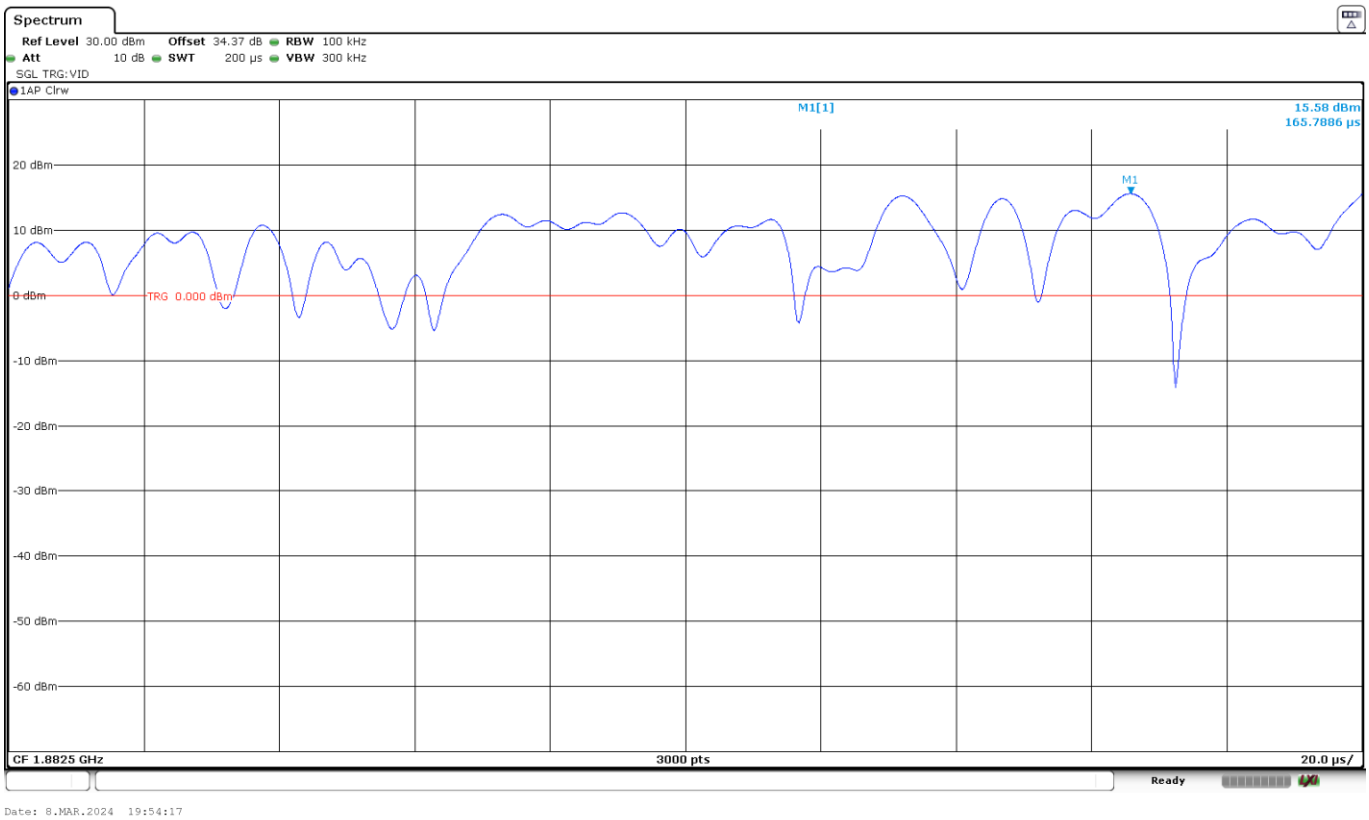
Test Setup



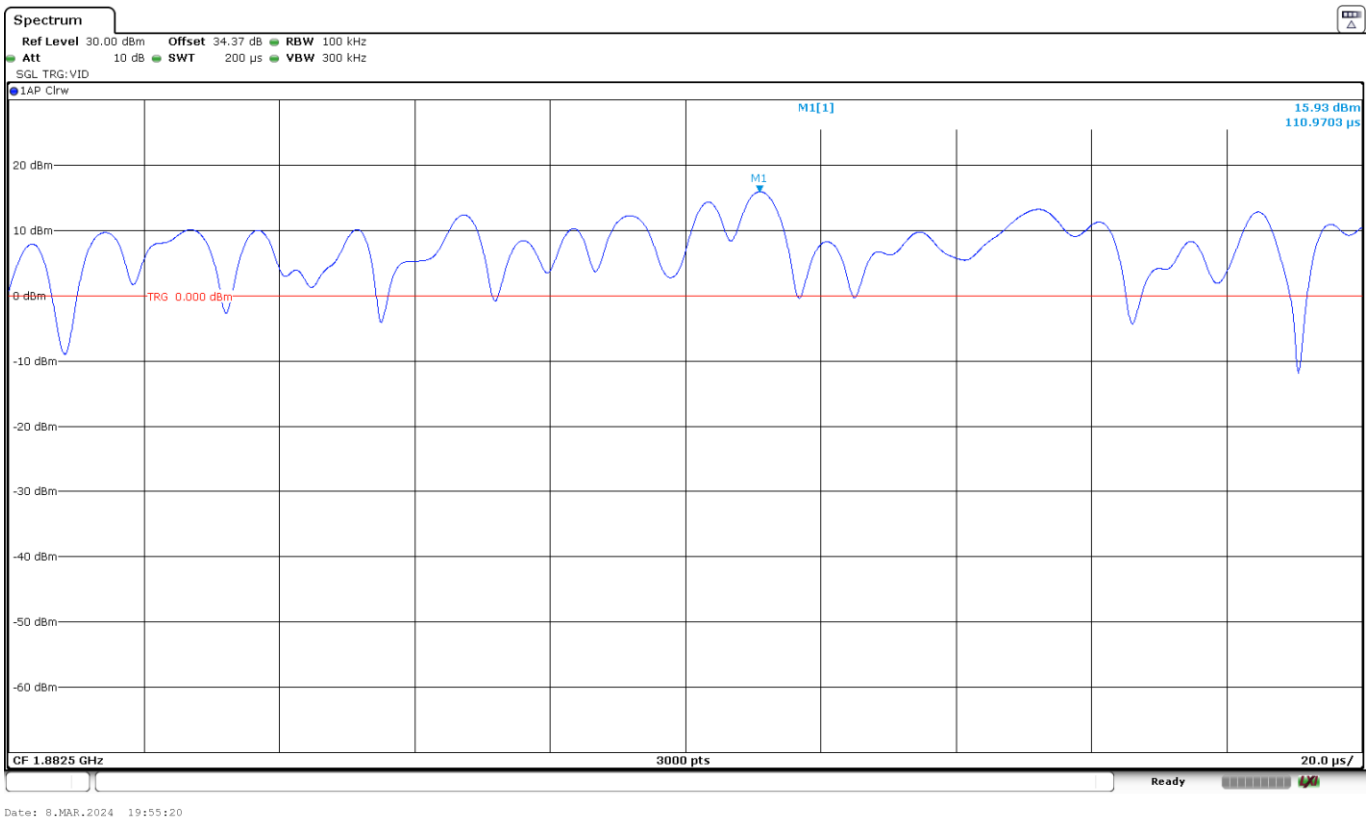
Results

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

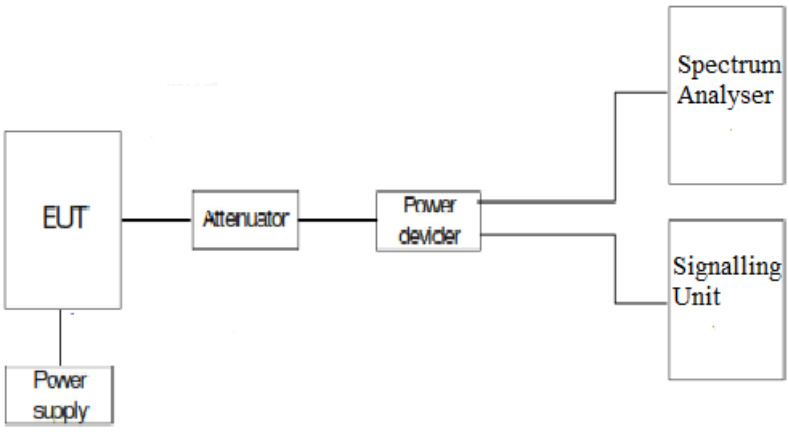
FCC §2.1049. Measurements required: Occupied bandwidth.

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. Narrowband=0.

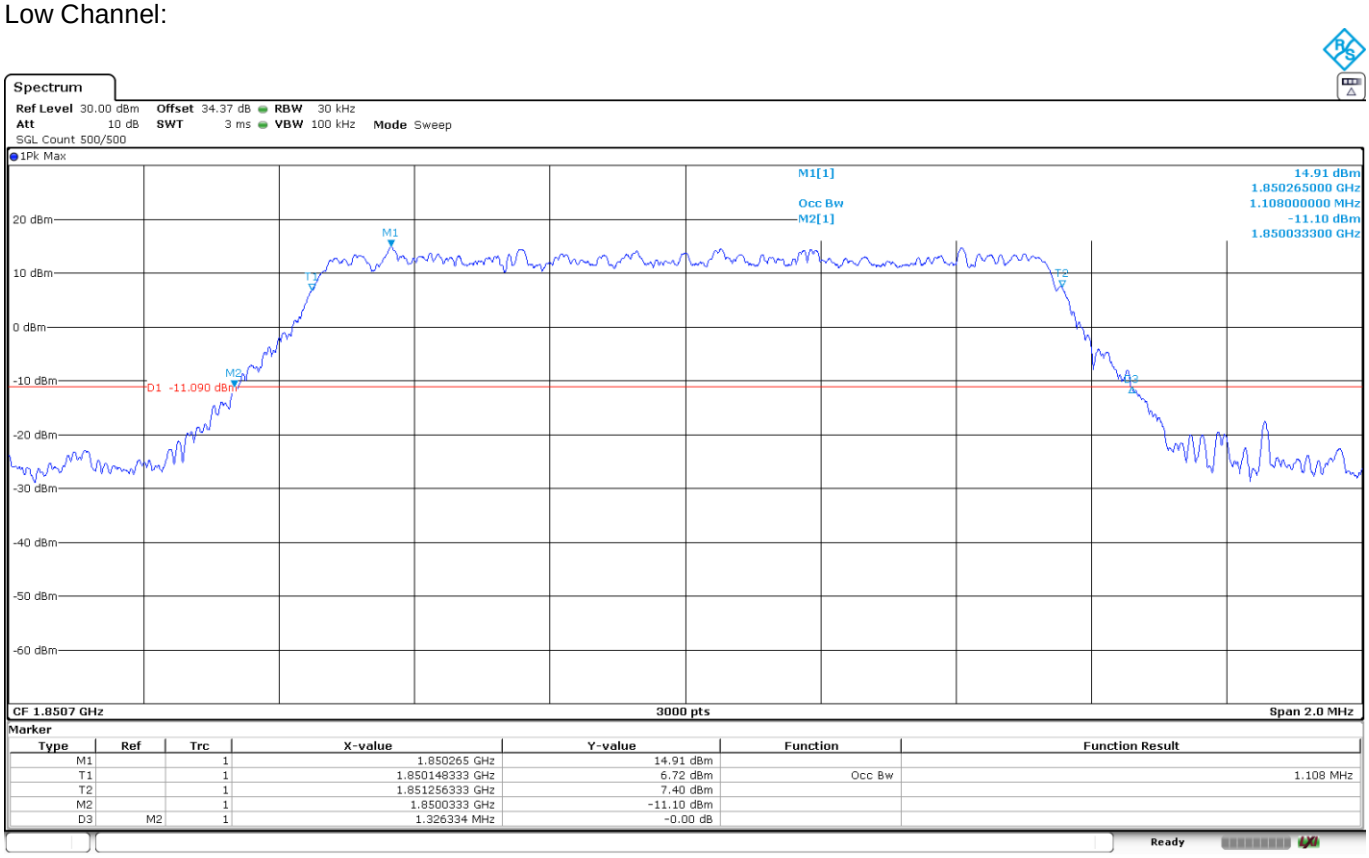
Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	1.10800	1.09933	1.09667
-26 dBc Bandwidth (MHz)	1.32633	1.32455	1.31455
Measurement uncertainty (kHz)	<±5.20		

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

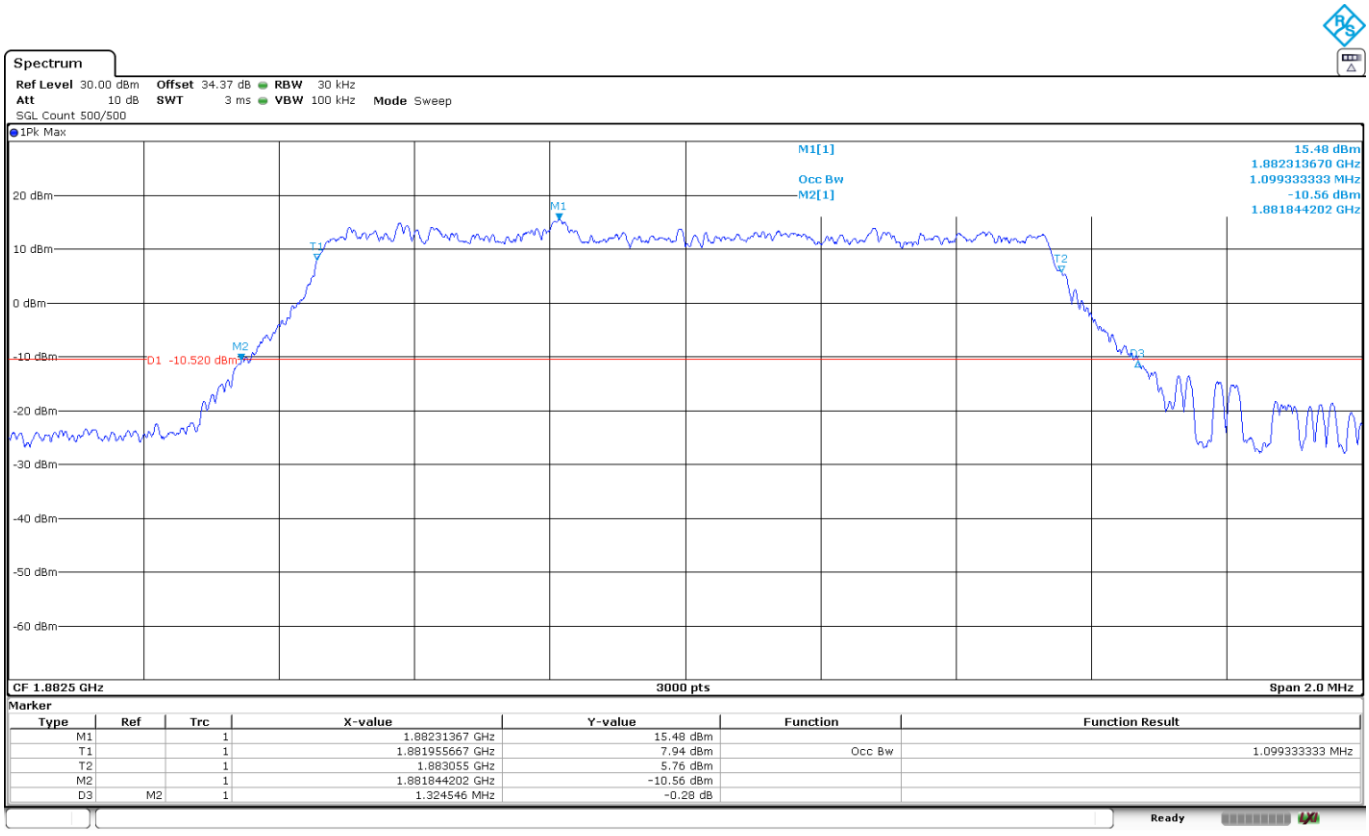
Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	0.96533	0.94400	0.94733
-26 dBc Bandwidth (MHz)	1.33699	1.29002	1.28820
Measurement uncertainty (kHz)	<±5.20		

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

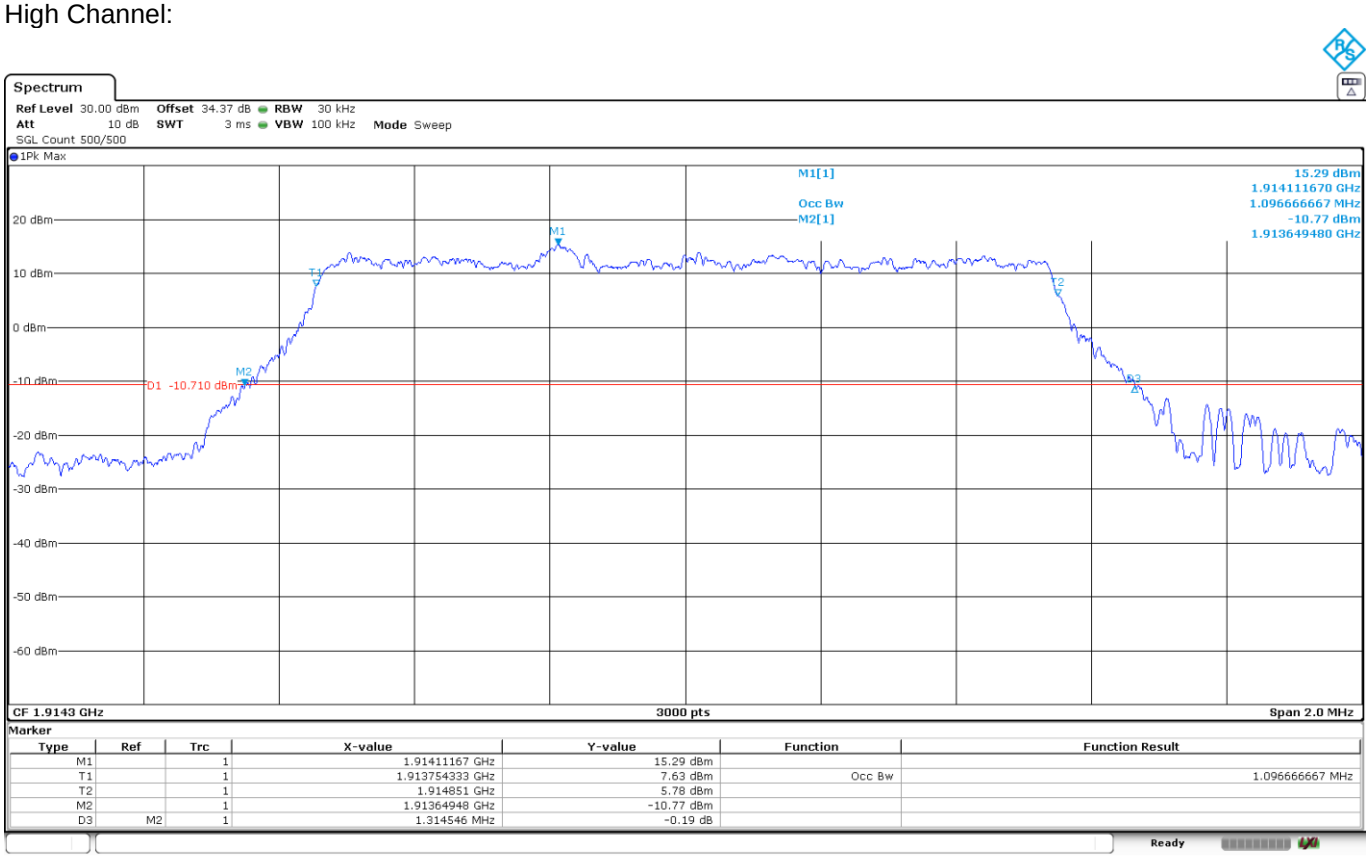
Low Channel:



Middle Channel:

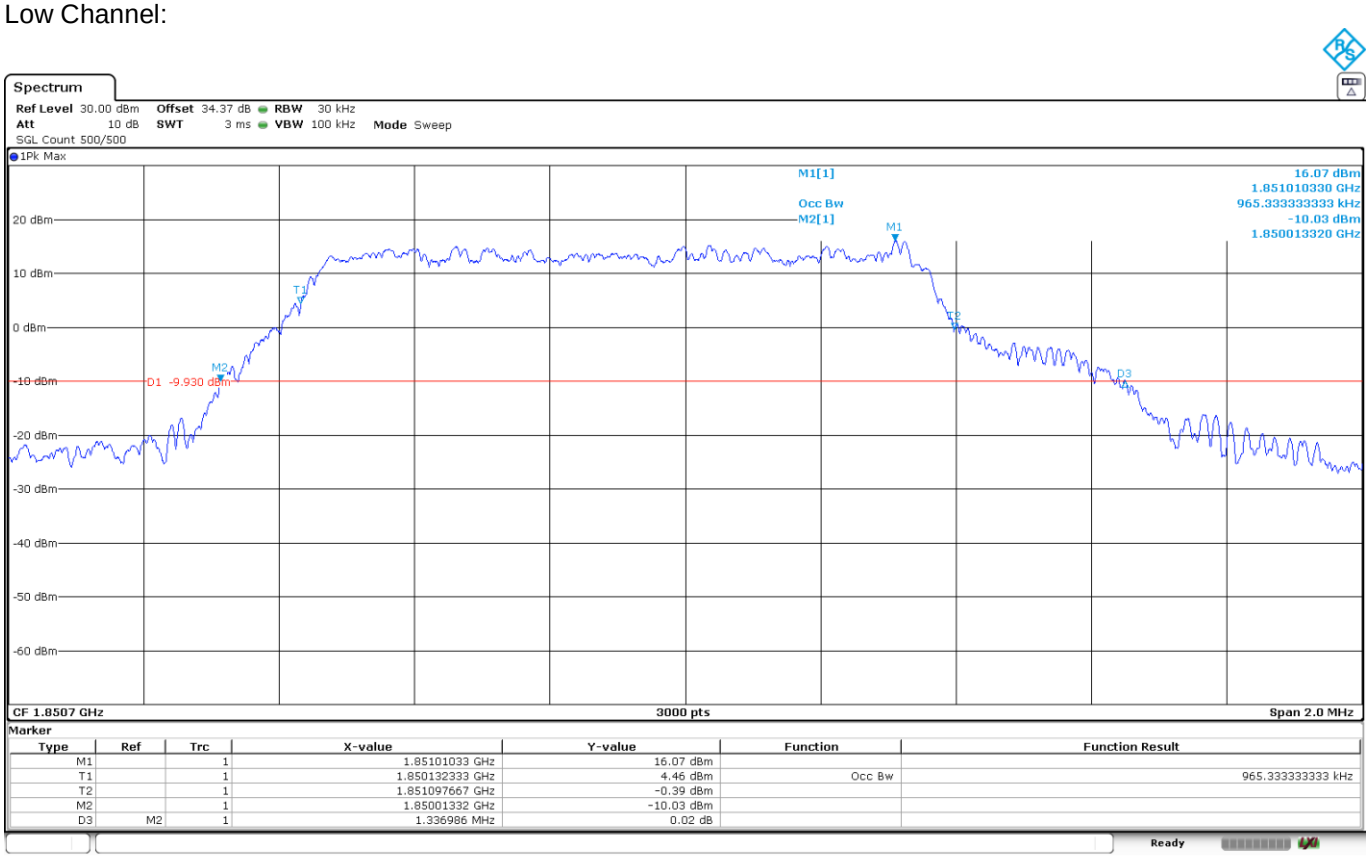


High Channel:

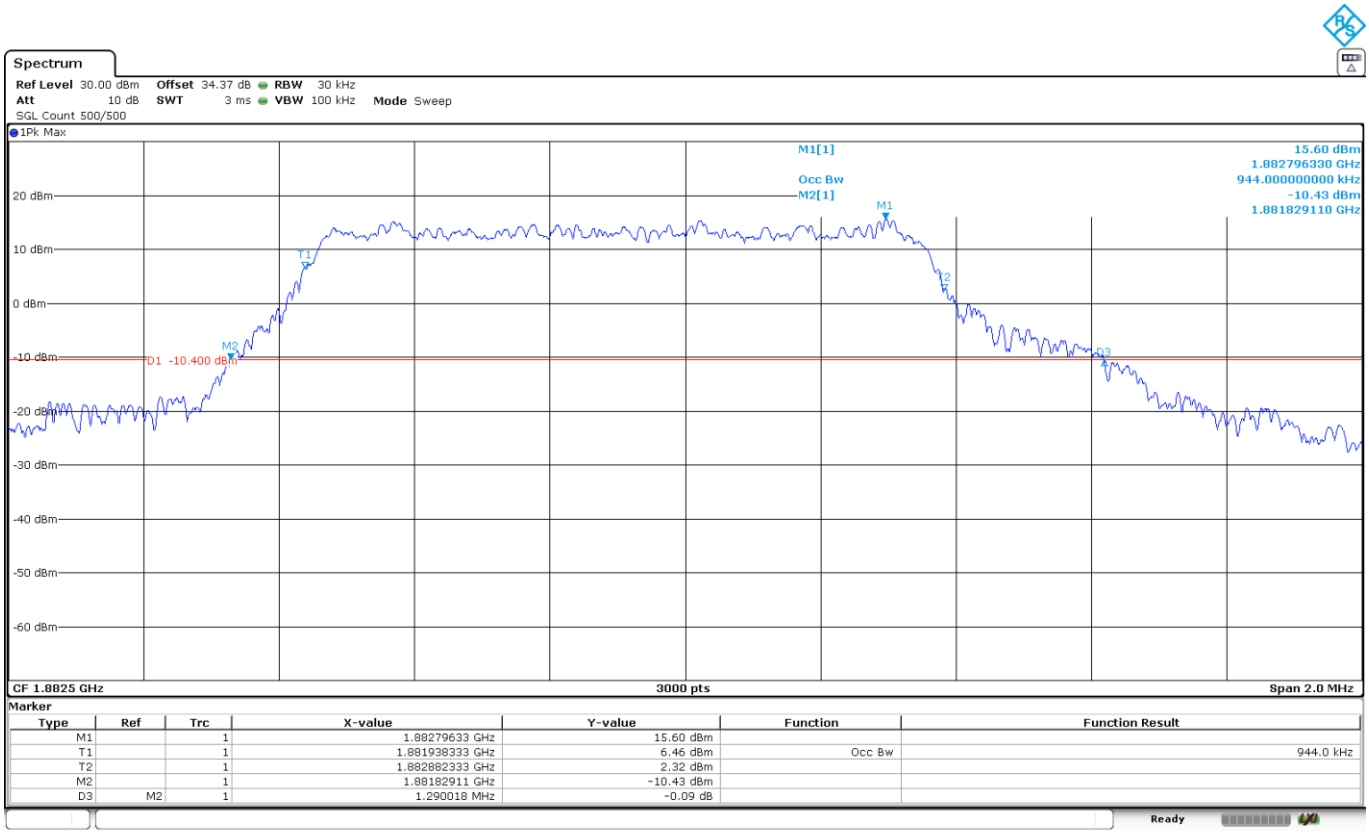


LTE Cat-M1 Band 25. BW=1.4 MHz. 16QAM. RB Size=5. RB Offset=0. Narrowband=0.

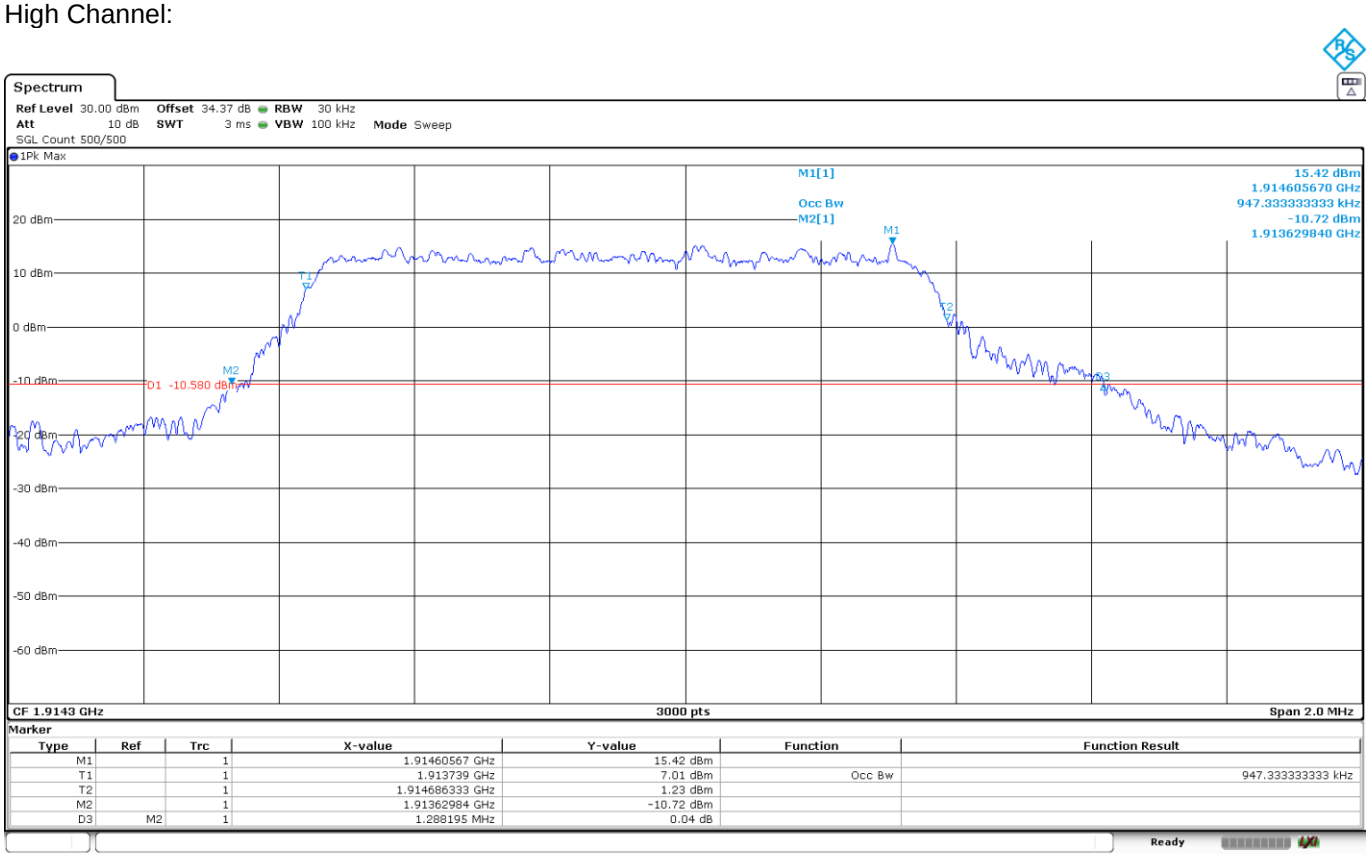
Low Channel:



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

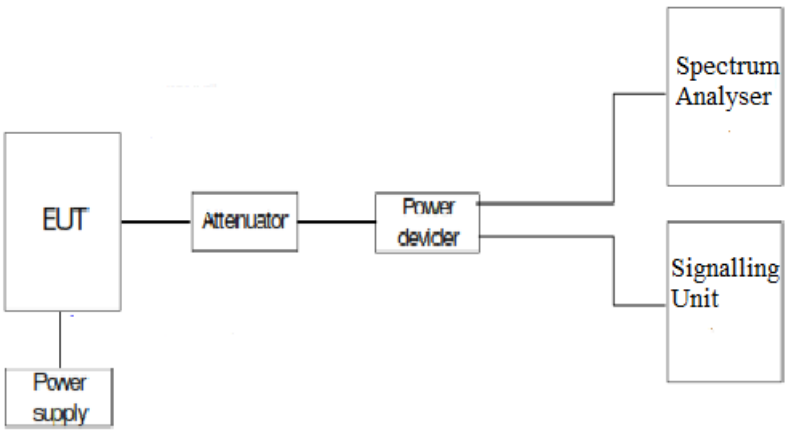
Method

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 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

LTE Cat-M1 Band 25:

A preliminary scan determined the worst-case:

BW=15 MHz. 16QAM. RB Size=5. RB Offset=0. Narrowband=0.

The next results are for this worst-case configuration.

Frequency range 9 KHz - 20 GHz:

- Low Channel: No spurious signals found.
- Middle Channel: No spurious signals found.
- High Channel: No spurious signals found.

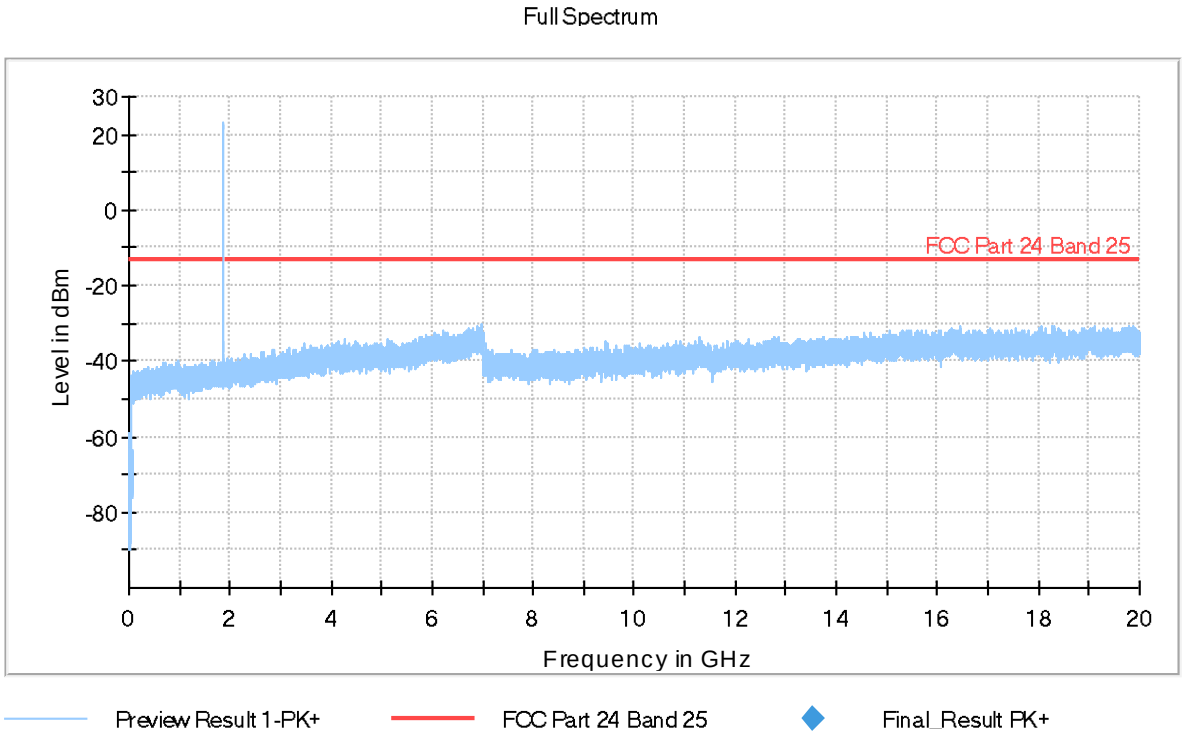
Measurement uncertainty (dB): <±2.76

Verdict: PASS

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
9 kHz - 150 kHz	14,1 Hz	PK+	300 Hz	Coupled	0 dB
150 kHz - 30 MHz	932,812 Hz	PK+	10 kHz	Coupled	0 dB
30 MHz - 1 GHz	303,125 kHz	PK+	1 MHz	Coupled	0 dB
1 GHz - 10 GHz	281,25 kHz	PK+	1 MHz	Coupled	0 dB
10 GHz - 20 GHz	312,5 kHz	PK+	1 MHz	Coupled	0 dB

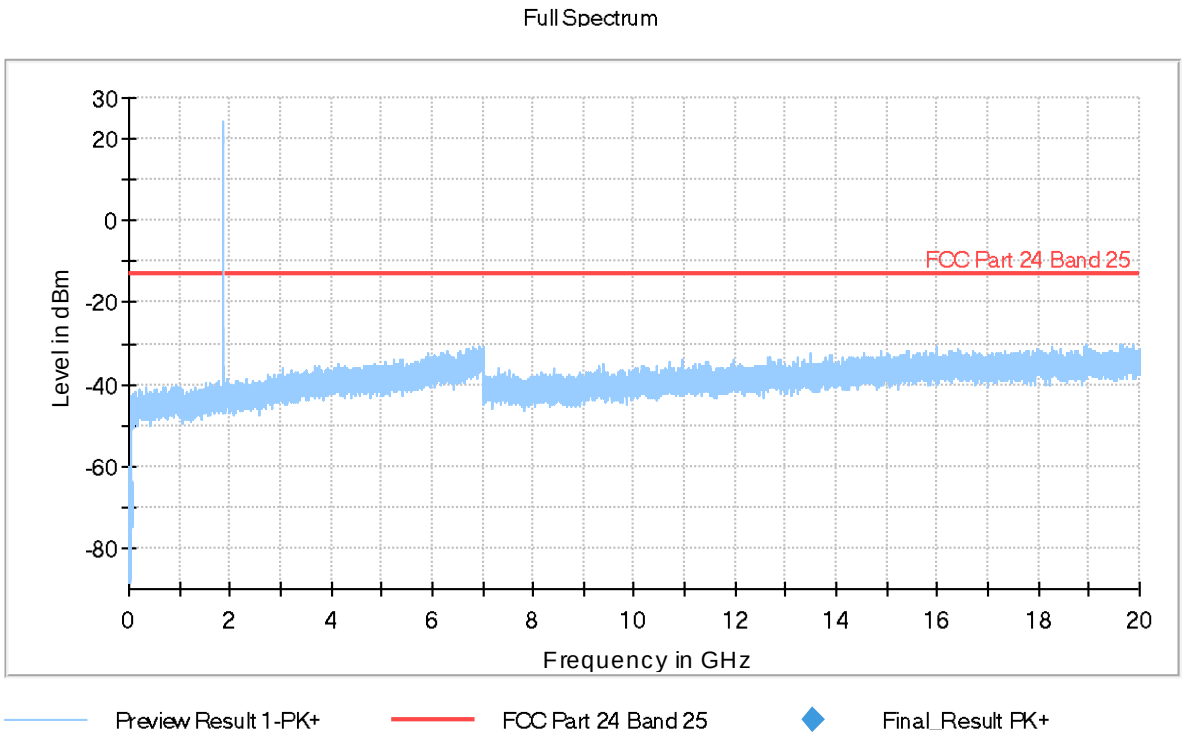
LTE Cat-M1 Band 25: BW=15 MHz. 16QAM. RB Size=5. RB Offset=0. Narrowband=0.

Low Channel:



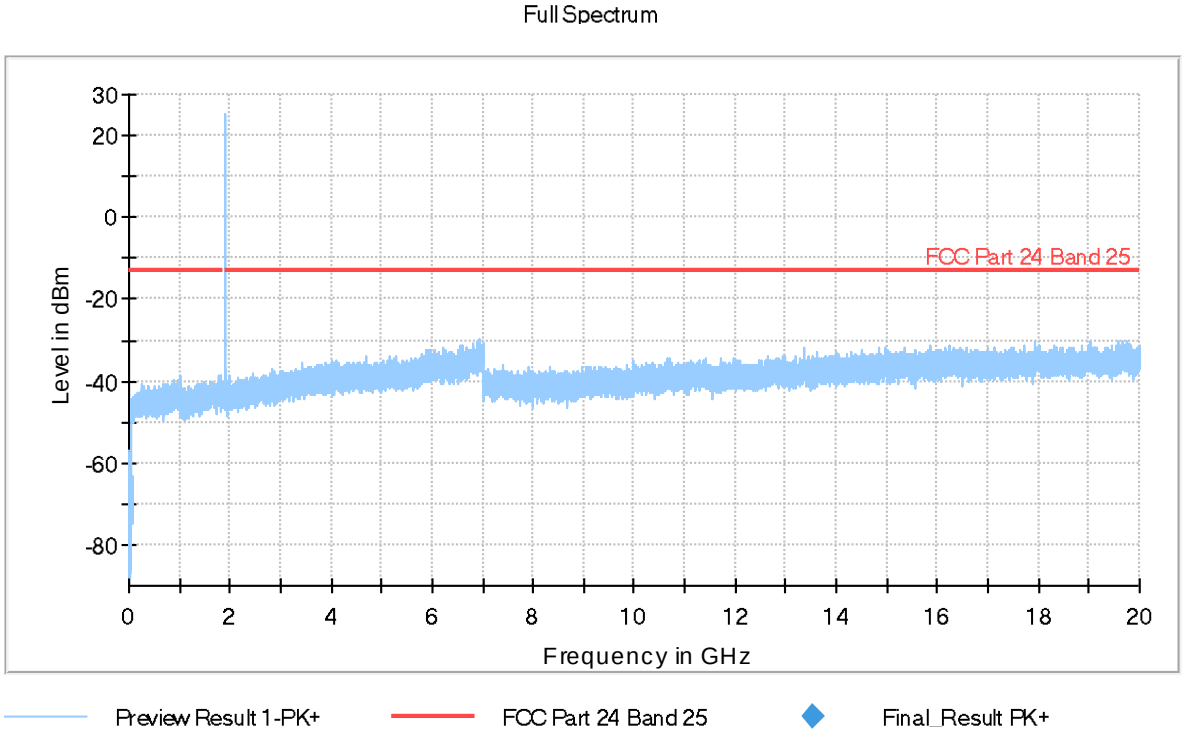
The peak above the limit is the carrier frequency.

Middle Channel:



The peak above the limit is the carrier frequency.

High Channel:



The peak above the limit is the carrier frequency.

Spurious Emissions at Antenna Terminals at Block Edges

Limits

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

> The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB.

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

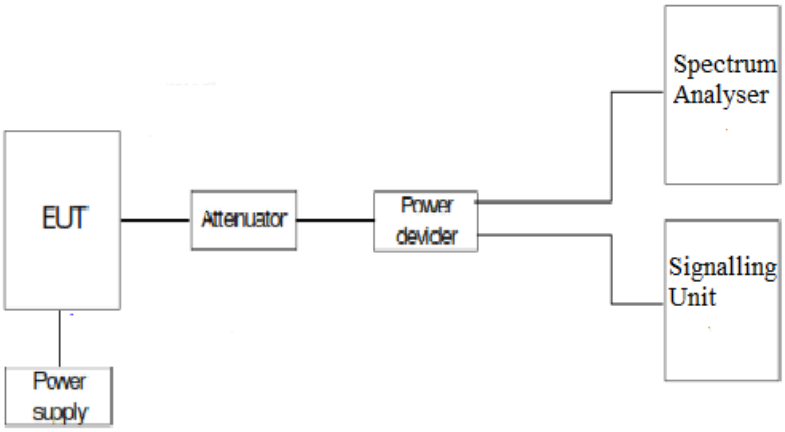
Method

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 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.

As stated in FCC part 24.238 / RSS-133 Clause 6.5, in the 1 MHz bands immediately outside and adjacent to the frequency block or band a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed.

Test Setup



Results

LTE Cat-M1 Band 2:

Preliminary measurements determined 16QAM, BW=1.4 MHz as the worst-case modulation in terms of band edge results. The next results are for this worst-case configuration.

Low Block Edge. Narrowband= 0.

Note: Low Block Edge for LTE Cat-M1 Band 2 is the same as for LTE Cat-M1 Band 25.

High Block Edge. Narrowband= Max.

LTE Cat-M1 Band 25. 16QAM.	RB=1. Offset=Max. BW=1.4 MHz	RB=1. Offset =Max. BW = 3 MHz	RB=1. Offset =Max. BW=5 MHz	RB=1. Offset =Max. BW=10 MHz	RB=1. Offset =Max. BW=15 MHz	RB=1. Offset =Max. BW=20 MHz
Maximum measured level at High Block Edge at antenna port (dBm)	-16.49	-21.86	-21.33	-21.85	-28.76	-31.73

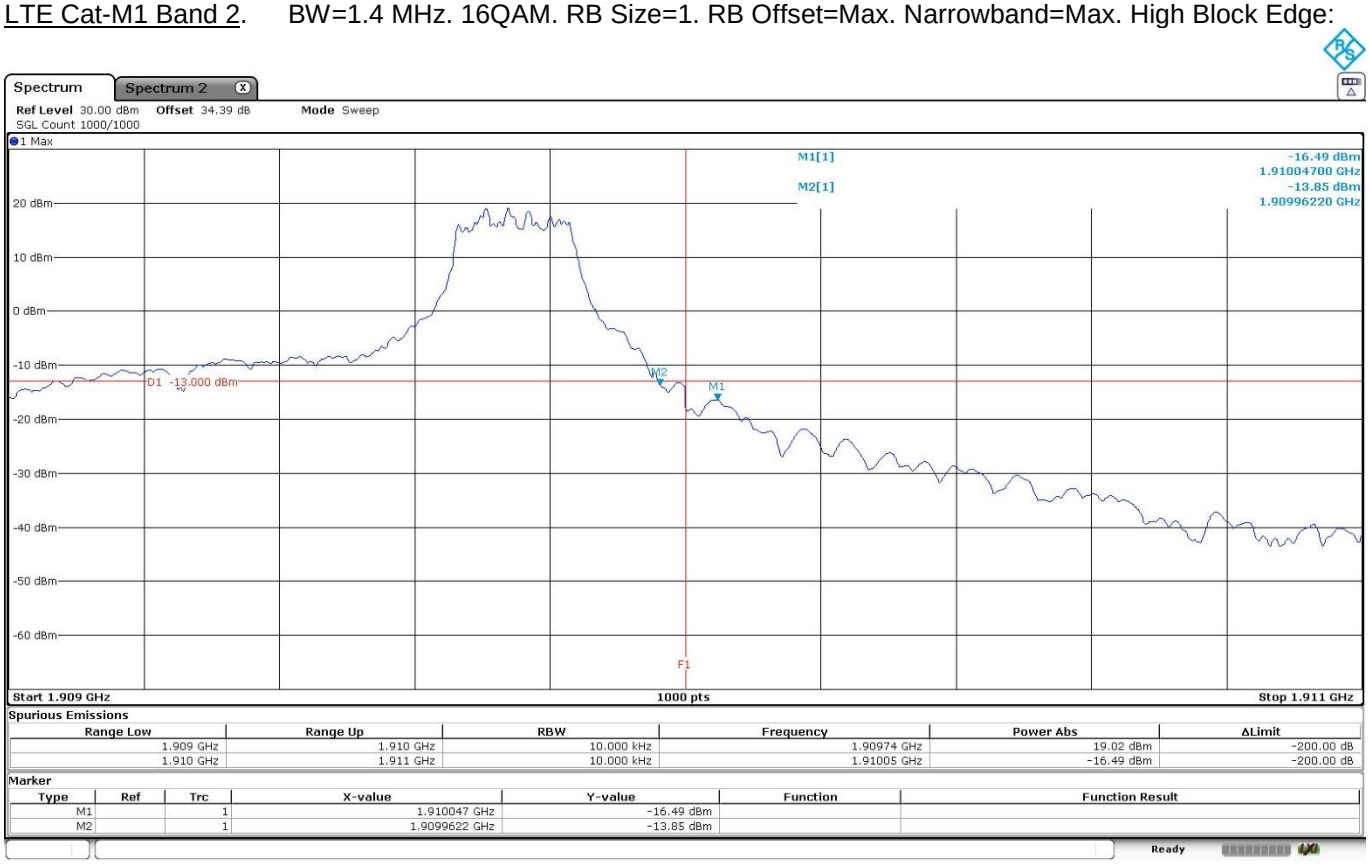
LTE Cat-M1 Band 25. 16QAM.	RB=5. Offset=1. BW=1.4 MHz	RB=5. Offset=1. BW = 3 MHz	RB=5. Offset=1. BW=5 MHz	RB=5. Offset=1. BW=10 MHz	RB=5. Offset=1. BW=15 MHz	RB=5. Offset=1. BW=20 MHz
Maximum measured level at High Block Edge at antenna port (dBm)	-14.38	-19.13	-17.89	-21.06	-27.01	-32.83

Measurement uncertainty: <±2.76 dB

Verdict

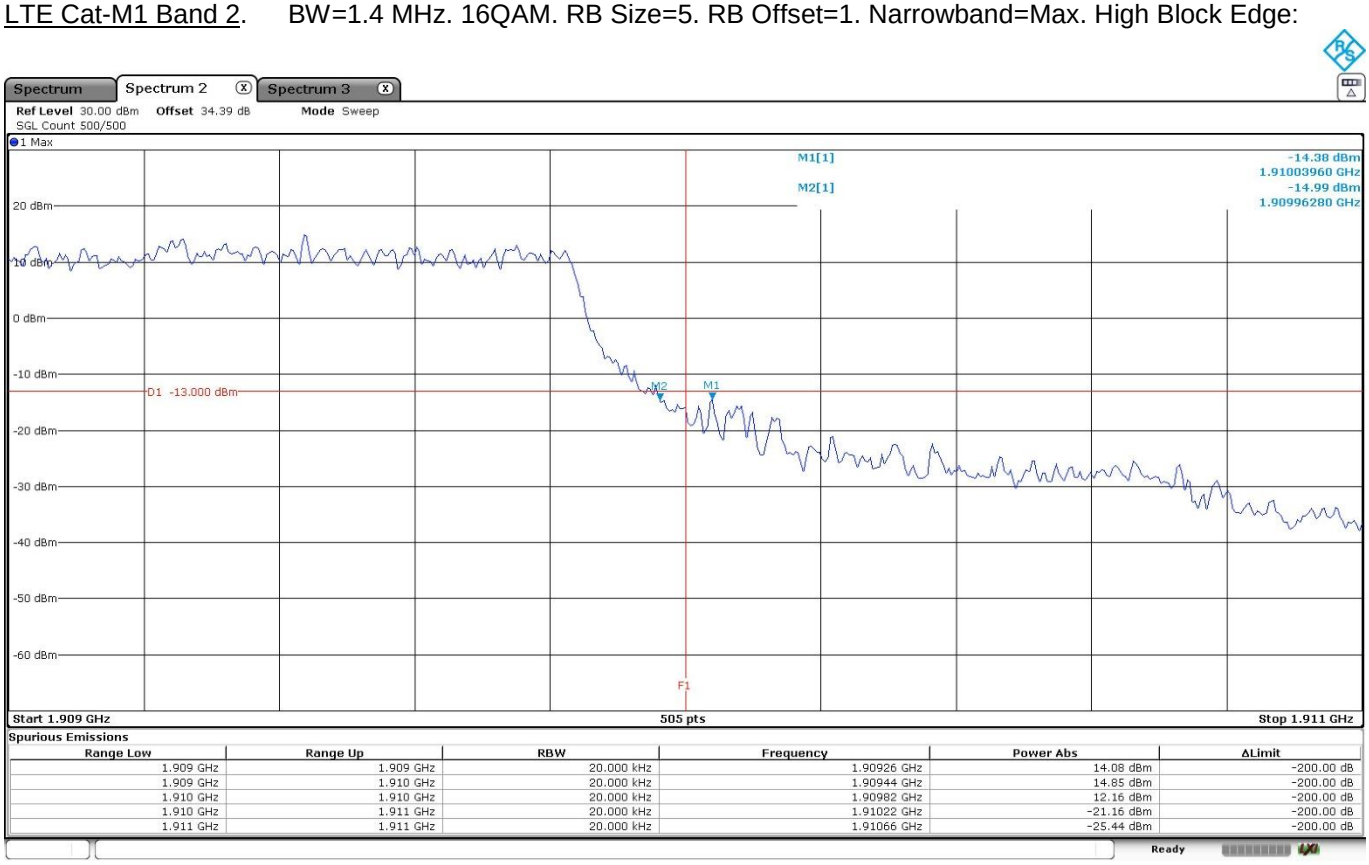
PASS

LTE Cat-M1 Band 2. BW=1.4 MHz. 16QAM. RB Size=1. RB Offset=Max. Narrowband=Max. High Block Edge:



The equipment transmits at the maximum output power.

LTE Cat-M1 Band 2. BW=1.4 MHz. 16QAM. RB Size=5. RB Offset=1. Narrowband=Max. High Block Edge:



The equipment transmits at the maximum output power.

LTE Cat-M1 Band 25:

Preliminary measurements determined 16QAM, BW=1.4 MHz as the worst-case modulation in terms of band edge results. The next results are for this worst-case configuration.

LTE Cat-M1 Band 25. 16QAM.	RB=1. Offset=0. BW=1.4 MHz	RB=1. Offset =0. BW = 3 MHz	RB=1. Offset =0. BW=5 MHz	RB=1. Offset =0. BW=10 MHz	RB=1. Offset =0. BW=15 MHz	RB=1. Offset =0. BW=20 MHz
Maximum measured level at Low Block Edge at antenna port (dBm)	-14.52	-15.78	-19.3	-29.42	-26.64	-31.17

LTE Cat-M1 Band 25. 16QAM.	RB=5. Offset=0. BW=1.4 MHz	RB=5. Offset=0. BW = 3 MHz	RB=5. Offset=0. BW=5 MHz	RB=5. Offset=0. BW=10 MHz	RB=5. Offset=0. BW=15 MHz	RB=5. Offset=0. BW=20 MHz
Maximum measured level at Low Block Edge at antenna port (dBm)	-17.51	-20.94	-19.94	-19.92	-26.66	-30.15

LTE Cat-M1 Band 25. 16QAM.	RB=1. Offset=Max. BW=1.4 MHz	RB=1. Offset =Max. BW = 3 MHz	RB=1. Offset =Max. BW=5 MHz	RB=1. Offset =Max. BW=10 MHz	RB=1. Offset =Max. BW=15 MHz	RB=1. Offset =Max. BW=20 MHz
Maximum measured level at High Block Edge at antenna port (dBm)	-15.5	-20.71	-19.42	-21.68	-26.39	-31.68

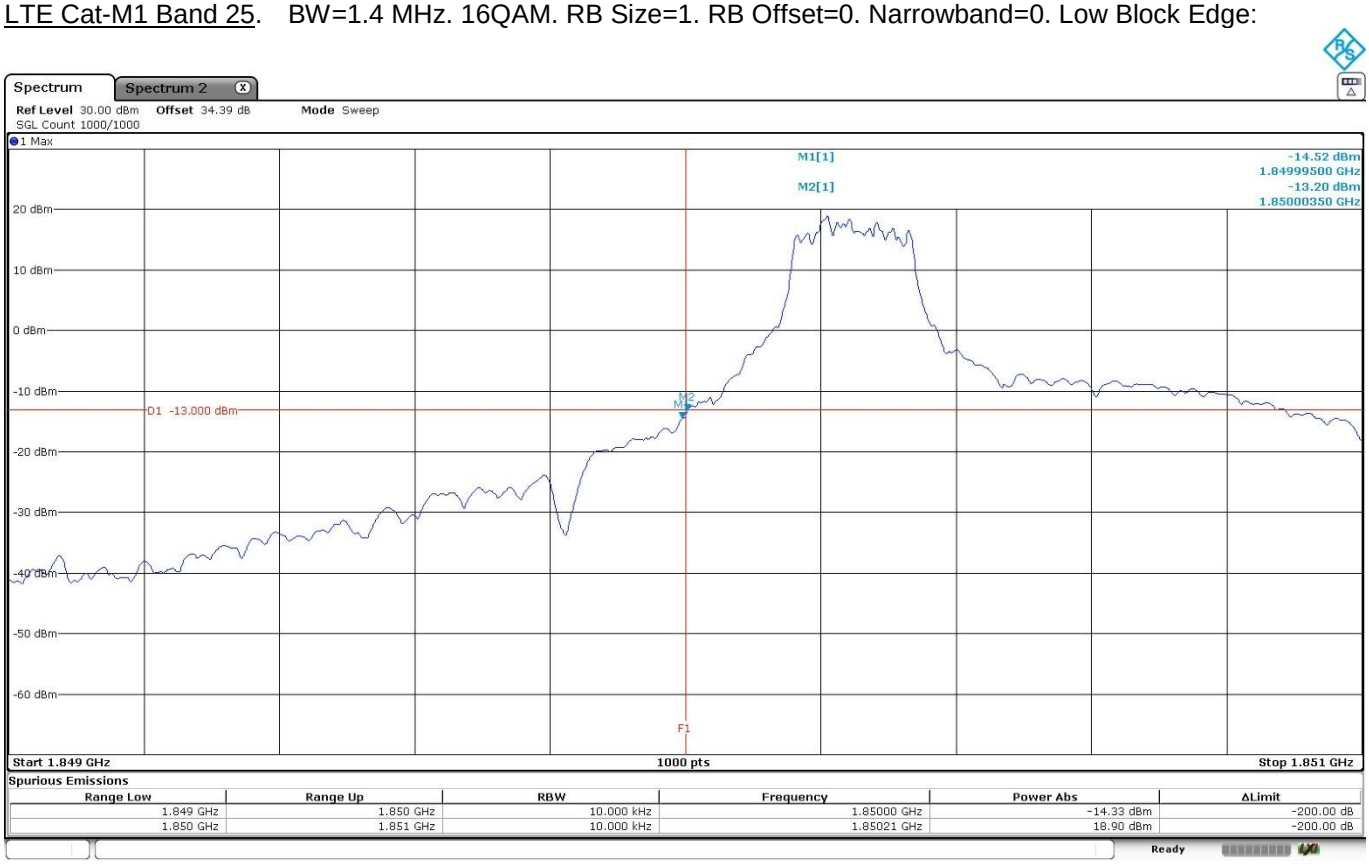
LTE Cat-M1 Band 25. 16QAM.	RB=5. Offset=1. BW=1.4 MHz	RB=5. Offset=1. BW = 3 MHz	RB=5. Offset=1. BW=5 MHz	RB=5. Offset=1. BW=10 MHz	RB=5. Offset=1. BW=15 MHz	RB=5. Offset=1. BW=20 MHz
Maximum measured level at High Block Edge at antenna port (dBm)	-14.18	-19.9	-18.05	-20.85	-27.2	-31.32

Measurement uncertainty (dB) <± 2.76

Verdict

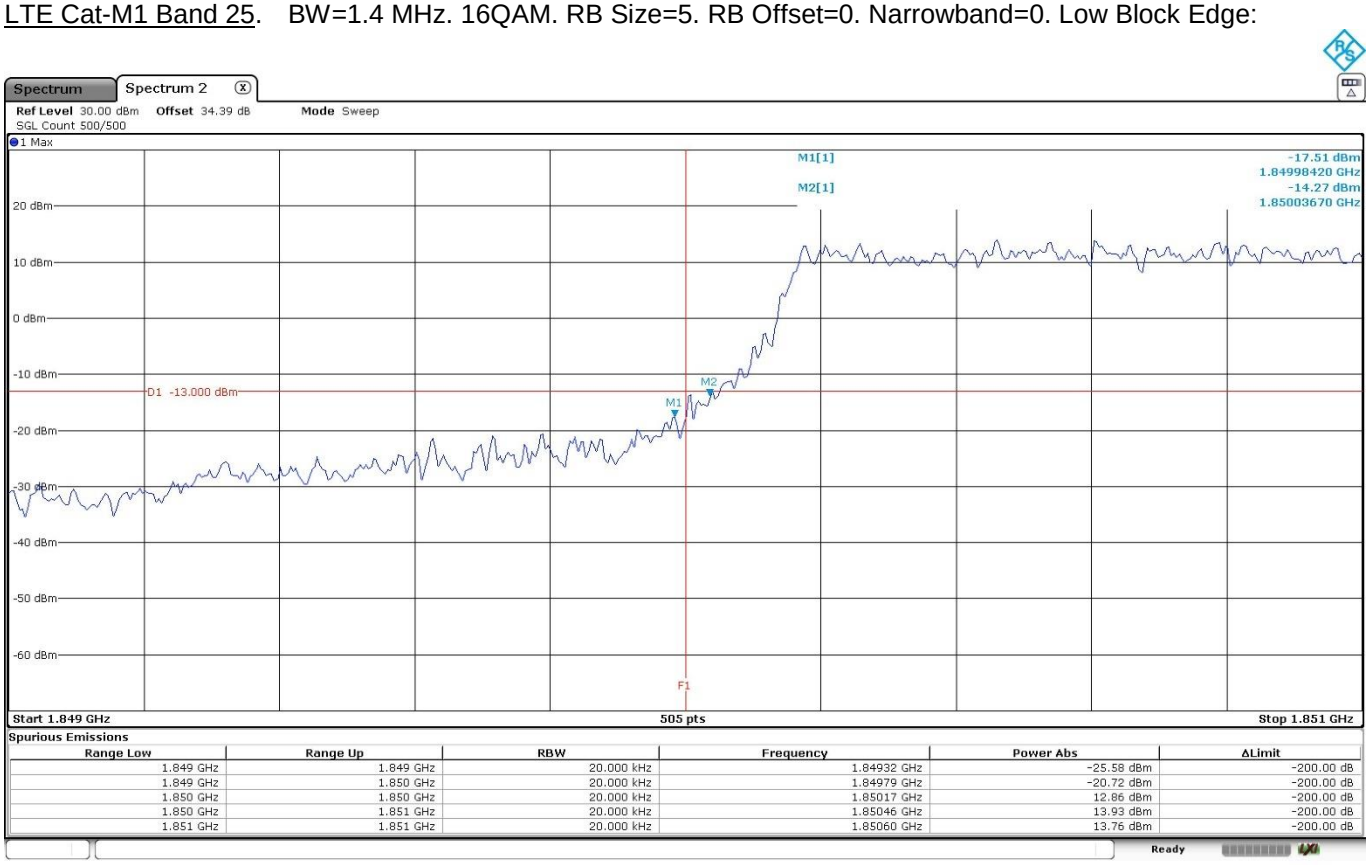
PASS

LTE Cat-M1 Band 25. BW=1.4 MHz. 16QAM. RB Size=1. RB Offset=0. Narrowband=0. Low Block Edge:



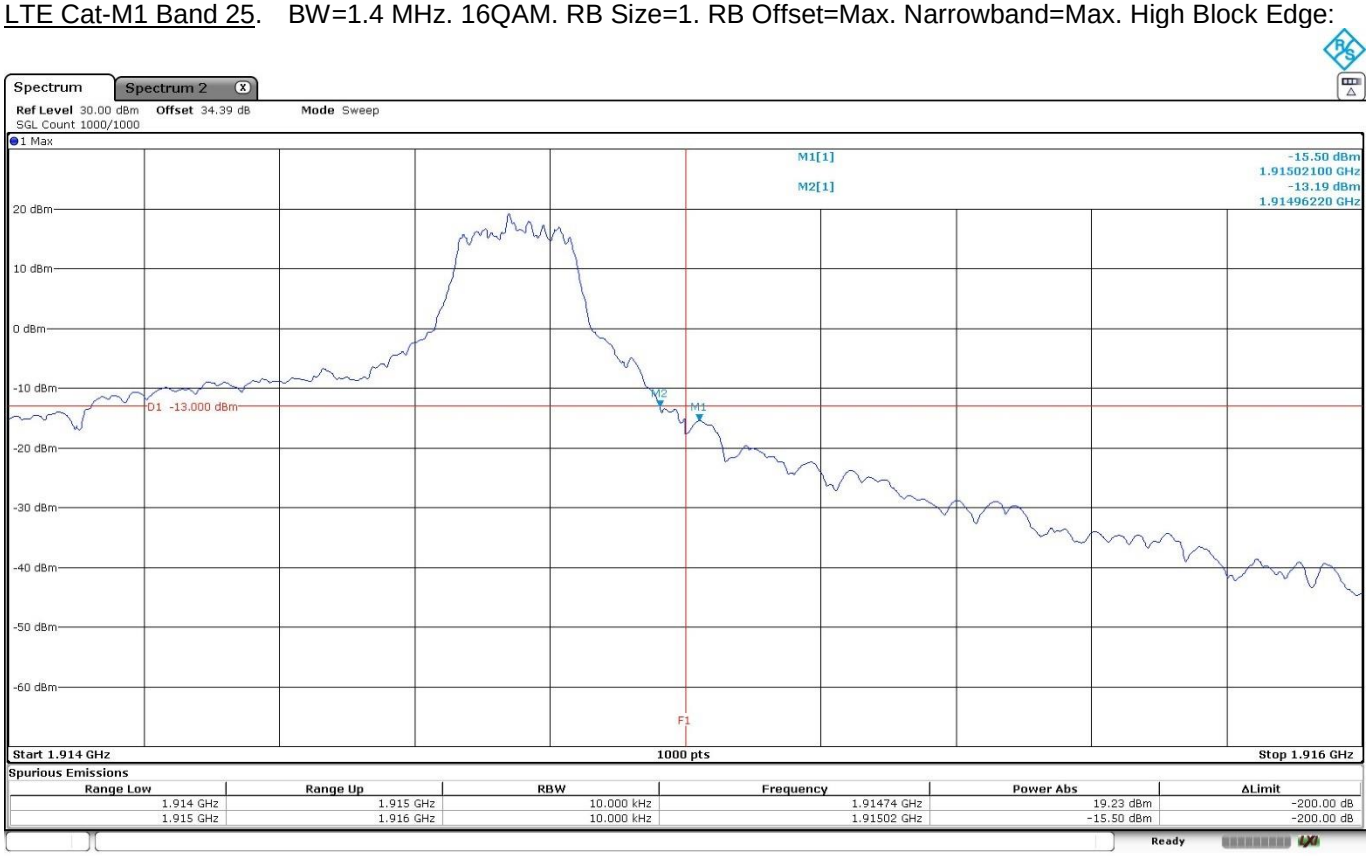
The equipment transmits at the maximum output power.

LTE Cat-M1 Band 25. BW=1.4 MHz. 16QAM. RB Size=5. RB Offset=0. Narrowband=0. Low Block Edge:



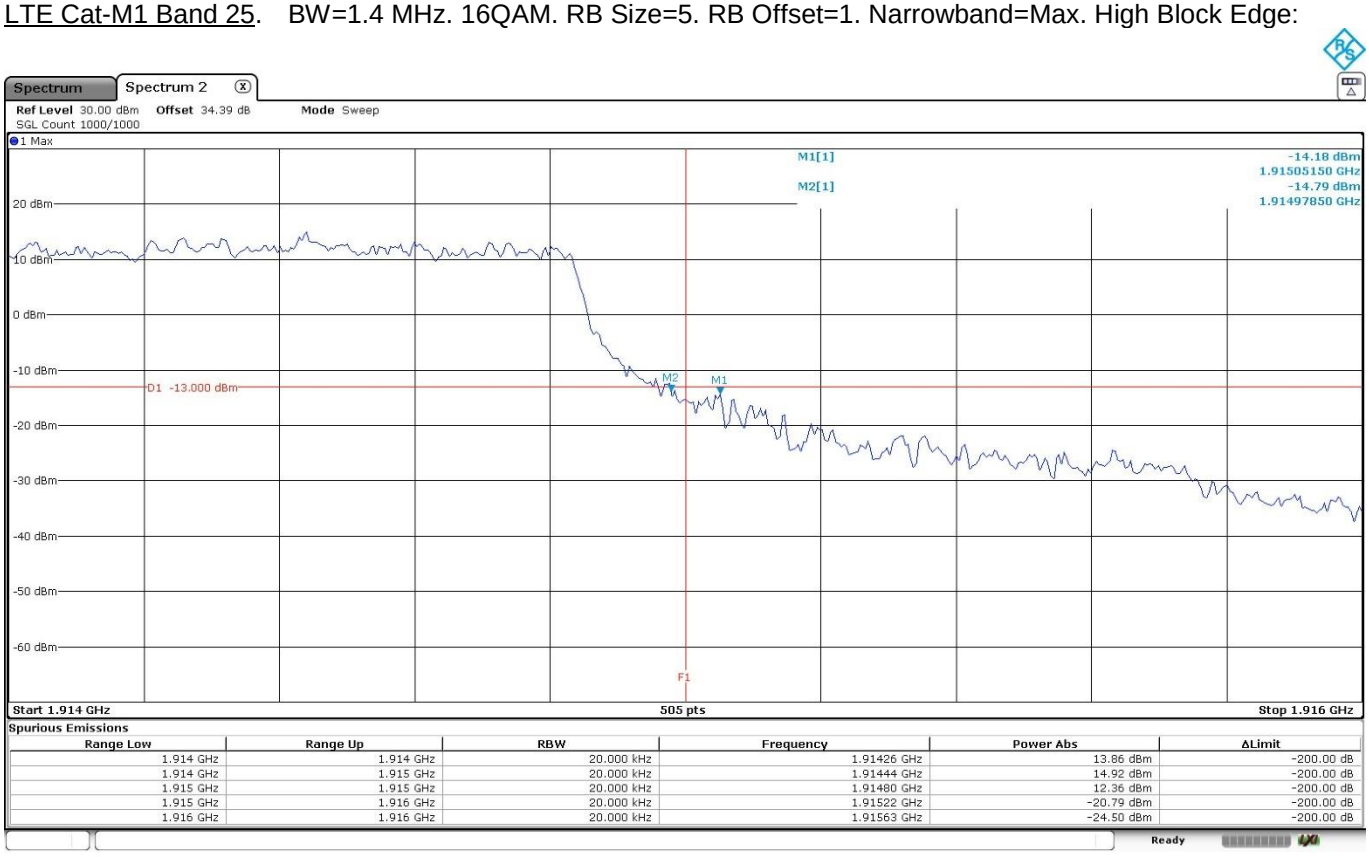
The equipment transmits at the maximum output power.

LTE Cat-M1 Band 25. BW=1.4 MHz. 16QAM. RB Size=1. RB Offset=Max. Narrowband=Max. High Block Edge:



The equipment transmits at the maximum output power.

LTE Cat-M1 Band 25. BW=1.4 MHz. 16QAM. RB Size=5. RB Offset=1. Narrowband=Max. High Block Edge:



The equipment transmits at the maximum output power.

Radiated Emissions

Limits

* FCC § 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.

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 High frequency generated within the equipment.

The EUT was placed on a non-conductive stand at 3-meter distance from the measuring antenna for measurements up to 17 GHz. Measurements above 17 GHz require the distance to be reduced to 1.5 meters.

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

Measurement Limit:

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

$$Po\ (dBm) - [43 + 10 \log (Po\ in\ mwatts) - 30] = -13\ dBm$$

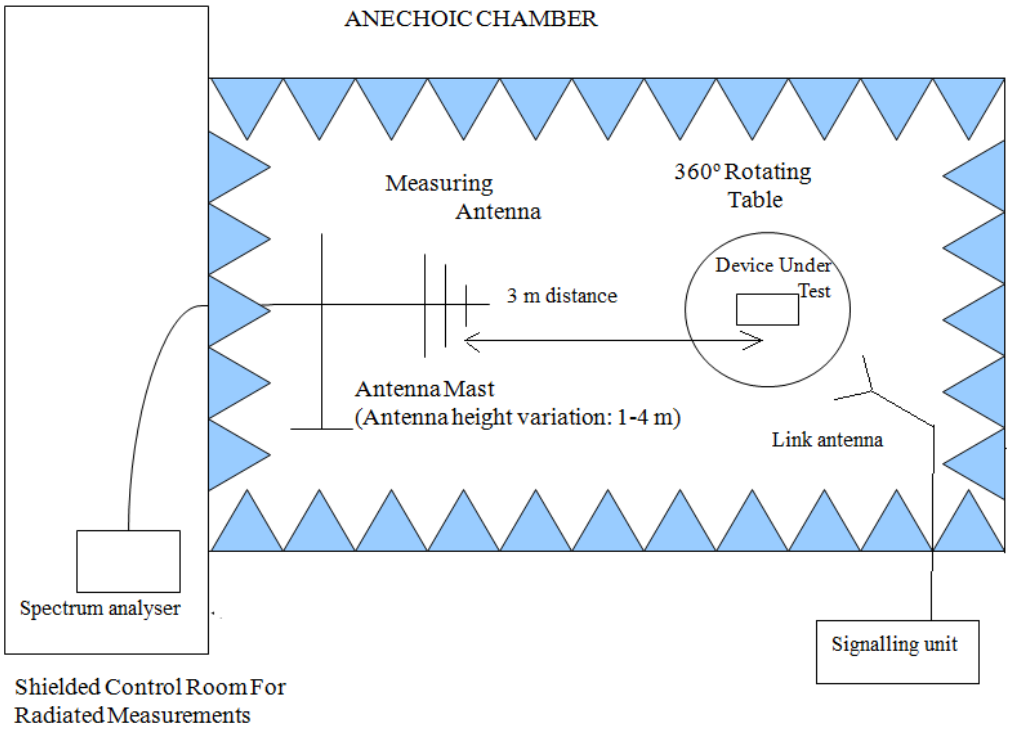
The maximum field strength (dBµV/m) of each detected emission at less than 20 dB respect to the limit is converted to an equivalent EIRP level (dBm) according to ANSI C63.26 with the formula:

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

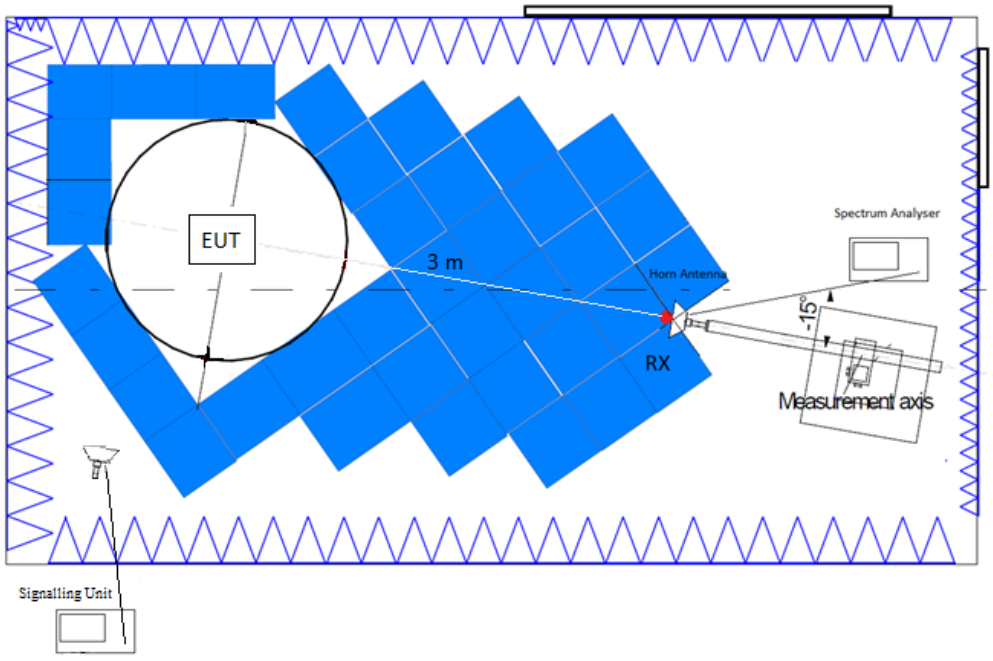
where D is the measurement distance (in the far field region) in m.

Test Setup

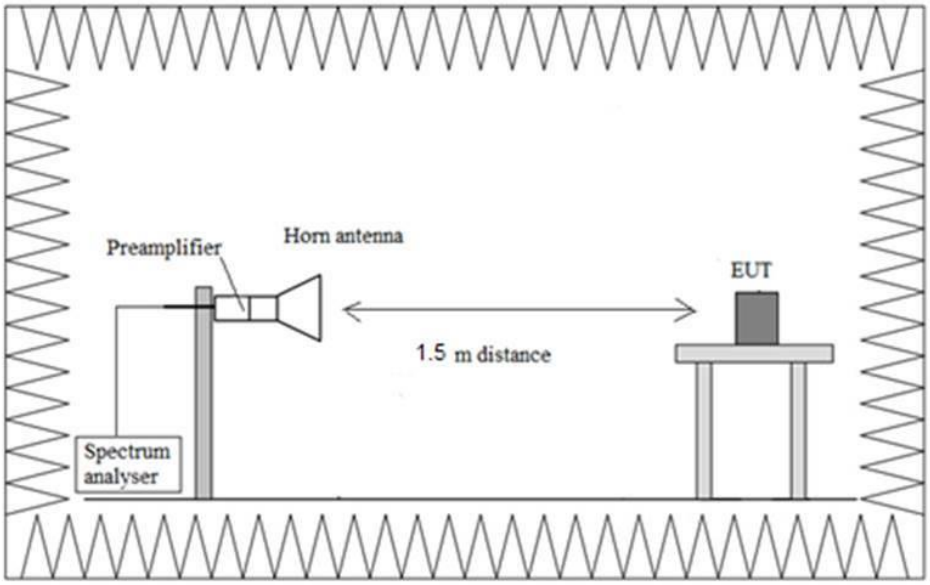
Radiated measurements below 1 GHz:



Radiated measurements above 1 GHz up to 17 GHz:



Radiated measurements above 17 GHz:



Results

LTE Cat-M1 Band 25:

A preliminary scan determined the BW=15 MHz, 16QAM, RB Size=5, RB Offset=0, Narrowband=11 as the worst case. The following results are for this worst-case configuration.

Frequency Range 30 MHz - 1 GHz:

- LOW CHANNEL:

No spurious signals were found at less than 20 dB below the limit.

- MIDDLE CHANNEL:

No spurious signals were found at less than 20 dB below the limit.

- HIGH CHANNEL:

No spurious signals were found at less than 20 dB below the limit.

Frequency Range 1 - 20 GHz:

- LOW CHANNEL:

No spurious signals were found at less than 20 dB below the limit.

- MIDDLE CHANNEL:

No spurious signals were found at less than 20 dB below the limit.

- HIGH CHANNEL:

No spurious signals were found at less than 20 dB below the limit.

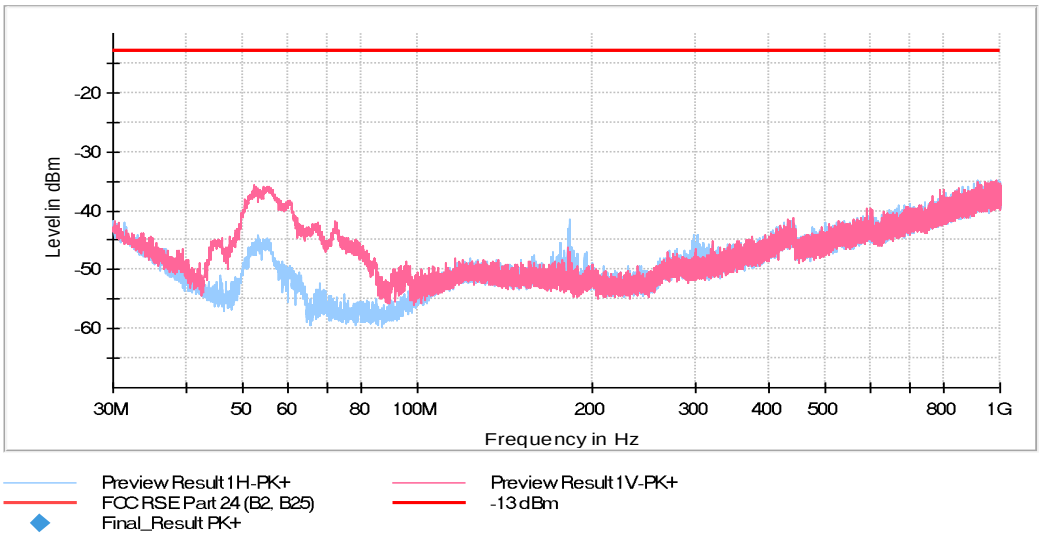
Measurement uncertainty (dB)	<± 5.03 for f < 1 GHz <± 4.32 for f ≥ 1 GHz up to 17 GHz <± 4.58 for f ≥ 17 GHz up to 20 GHz

Verdict *Pass*

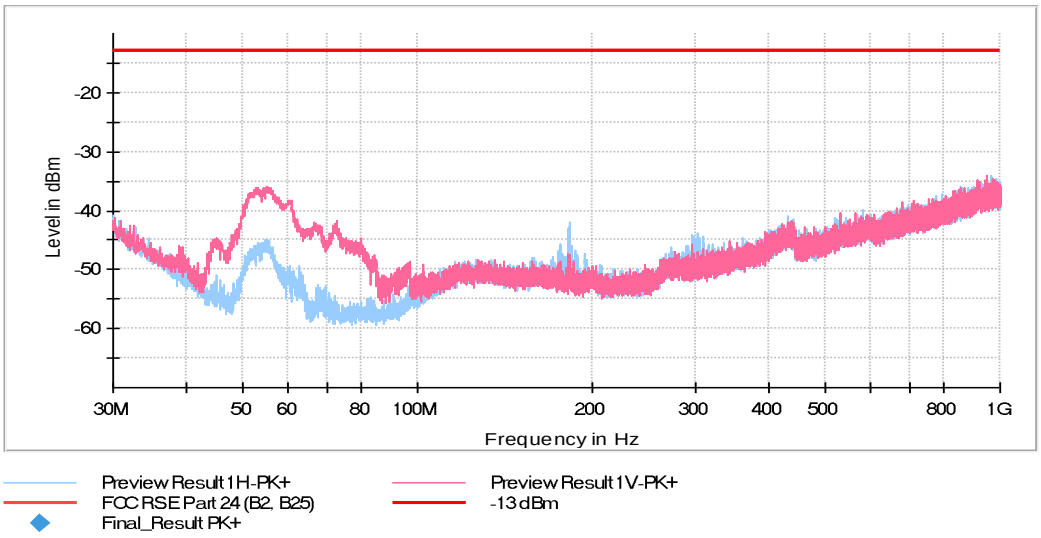
Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
30 MHz - 1 GHz	30,312 kHz	PK+	1 MHz	Coupled	0 dB
1 GHz - 3 GHz	62.5 kHz	PK+	1 MHz	1 s	0 dB
3 GHz - 17 GHz	437.5 kHz	PK+	1 MHz	1 s	0 dB
17 GHz - 20 GHz	93.75 kHz	PK+	1 MHz	1 s	0 dB

FREQUENCY RANGE 30 MHz - 1 GHz:

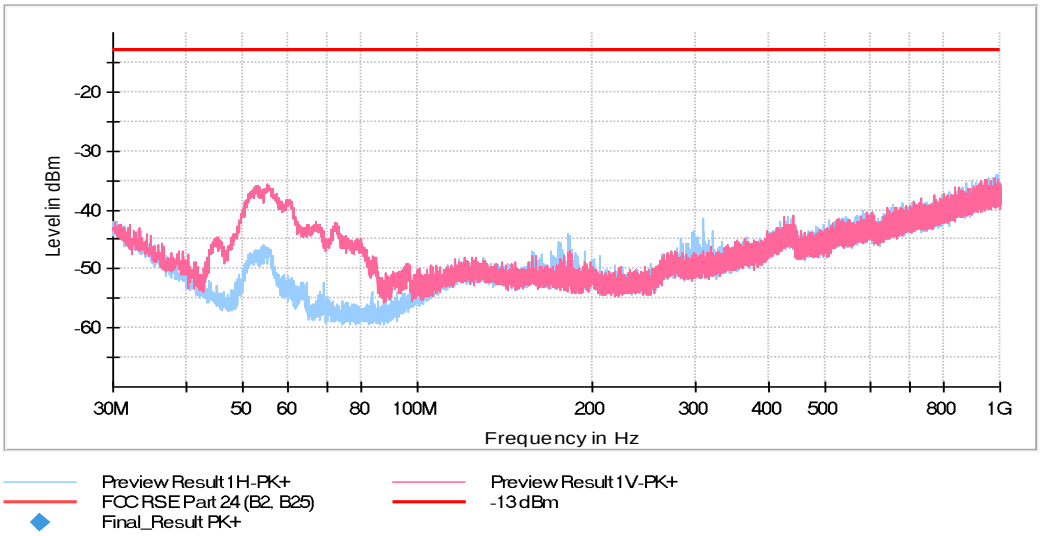
- Low Channel:



- Middle Channel:

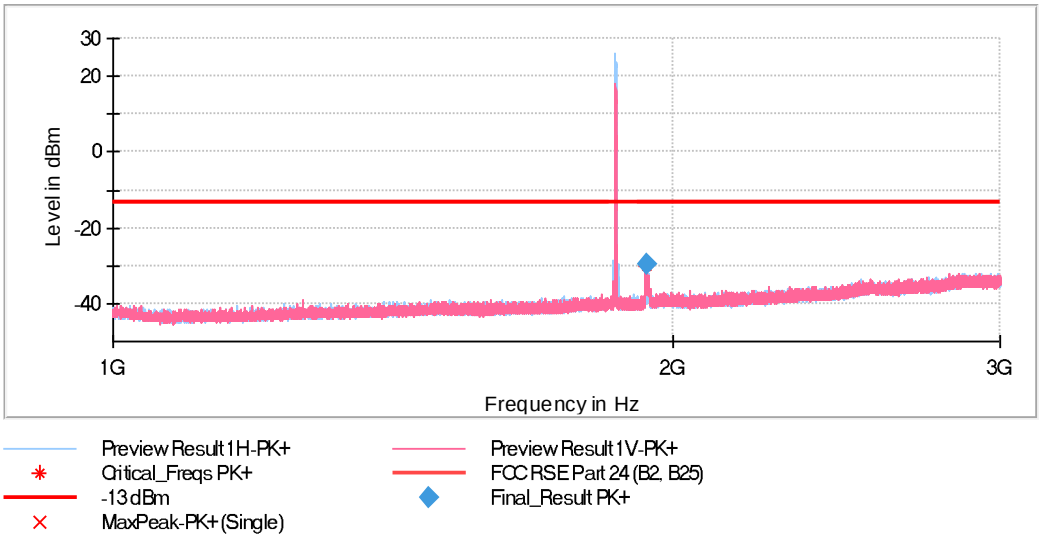


- High Channel:

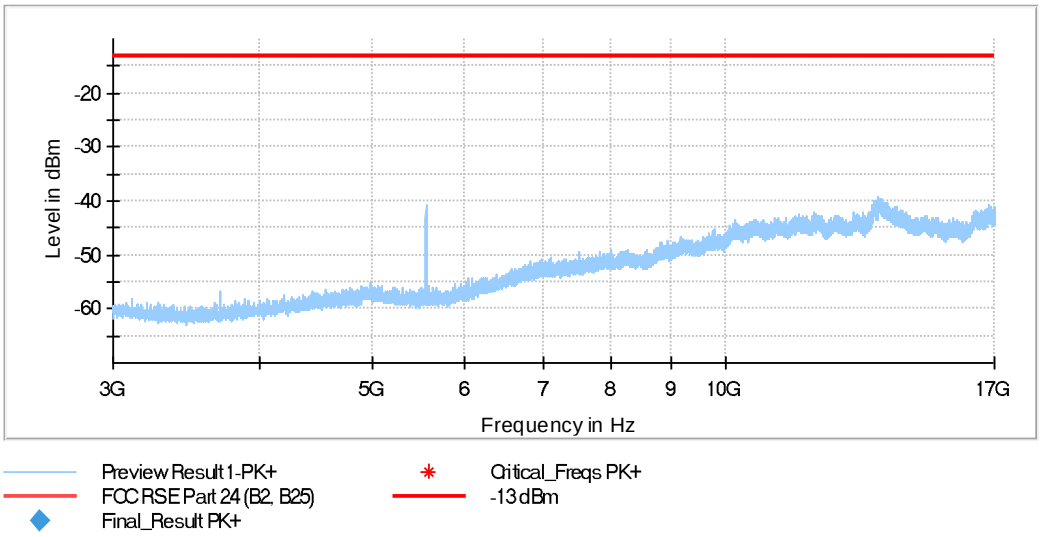


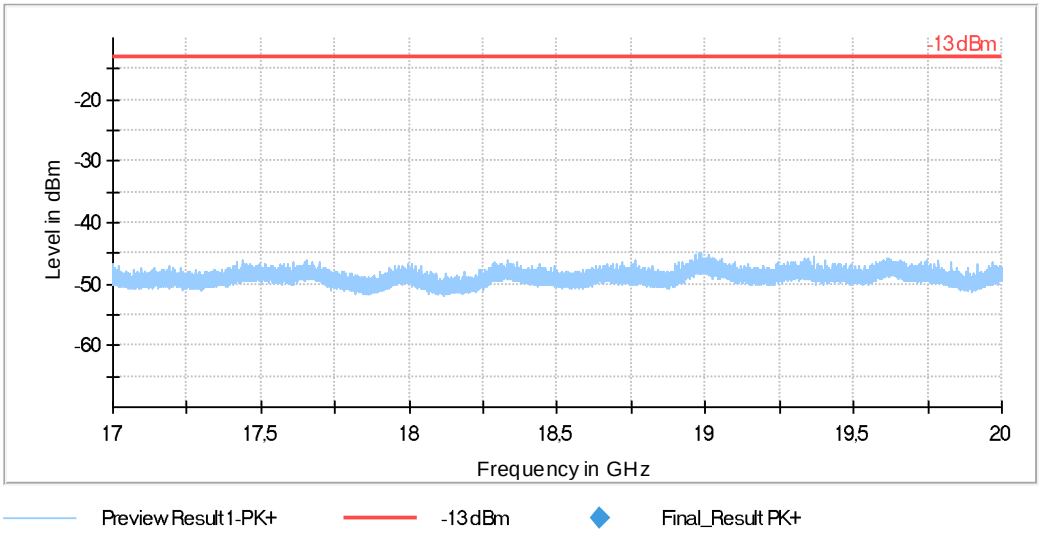
FREQUENCY RANGE 1 - 20 GHz:

- Low Channel:

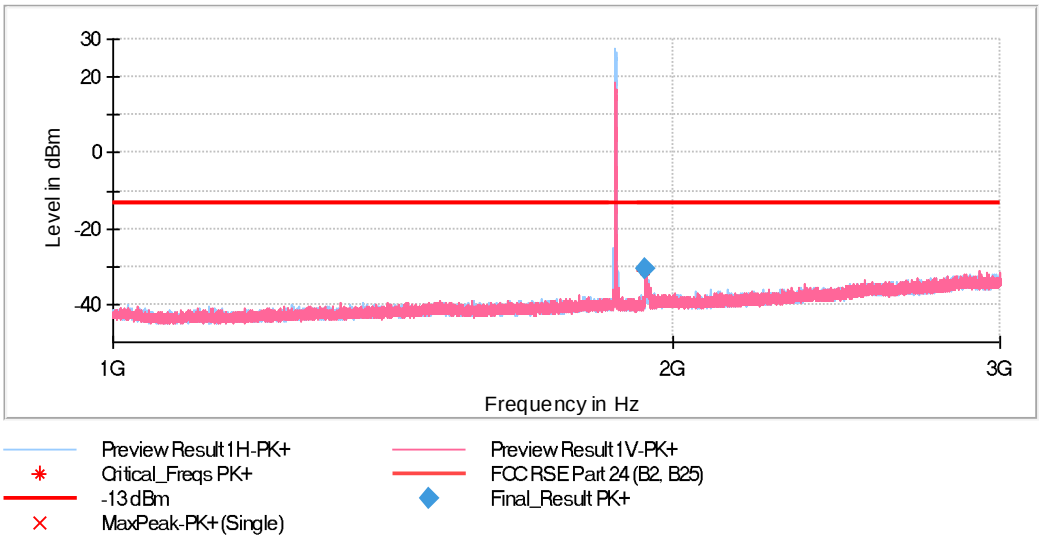


The peak above the limit is the carrier frequency.

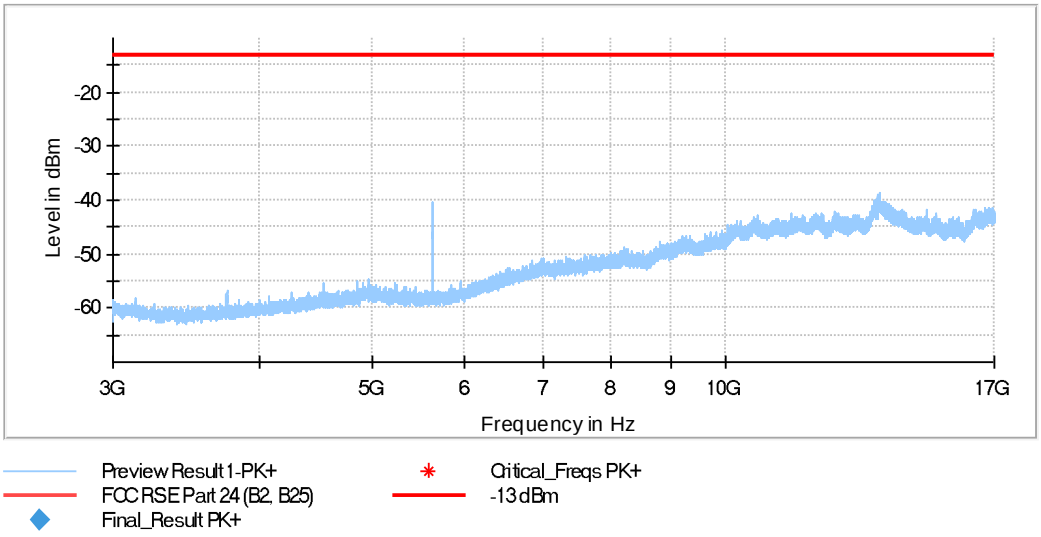


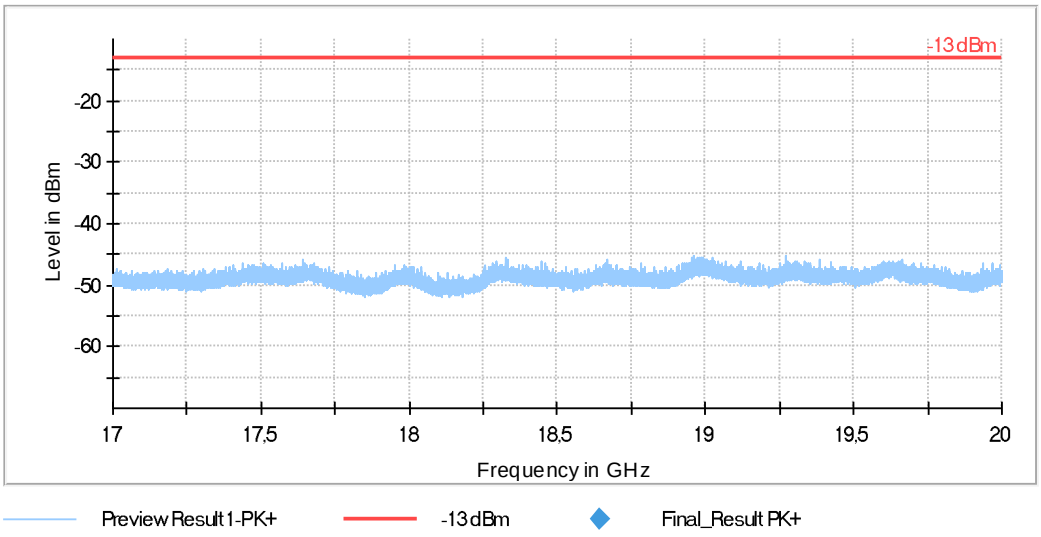


- Middle Channel:

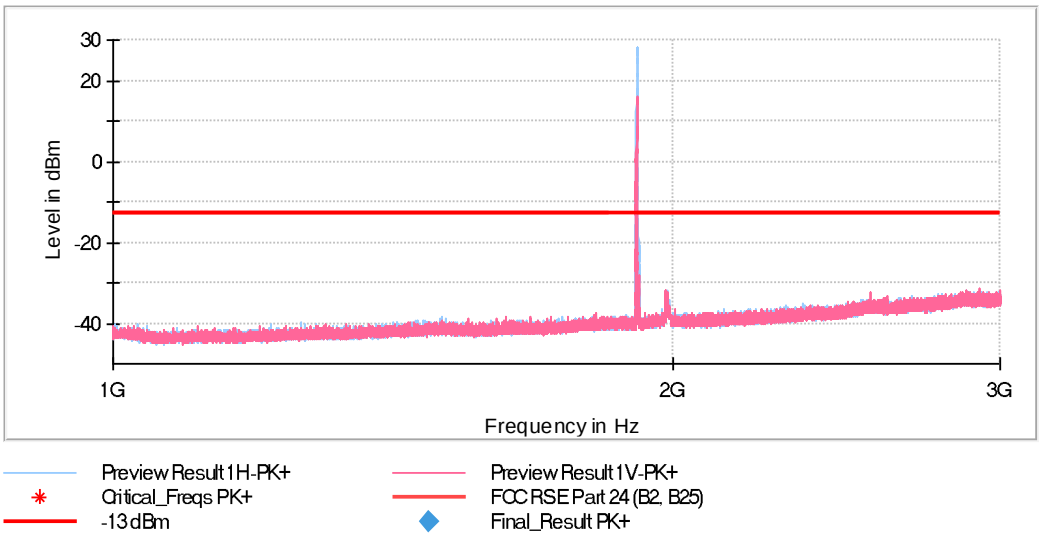


The peak above the limit is the carrier frequency.

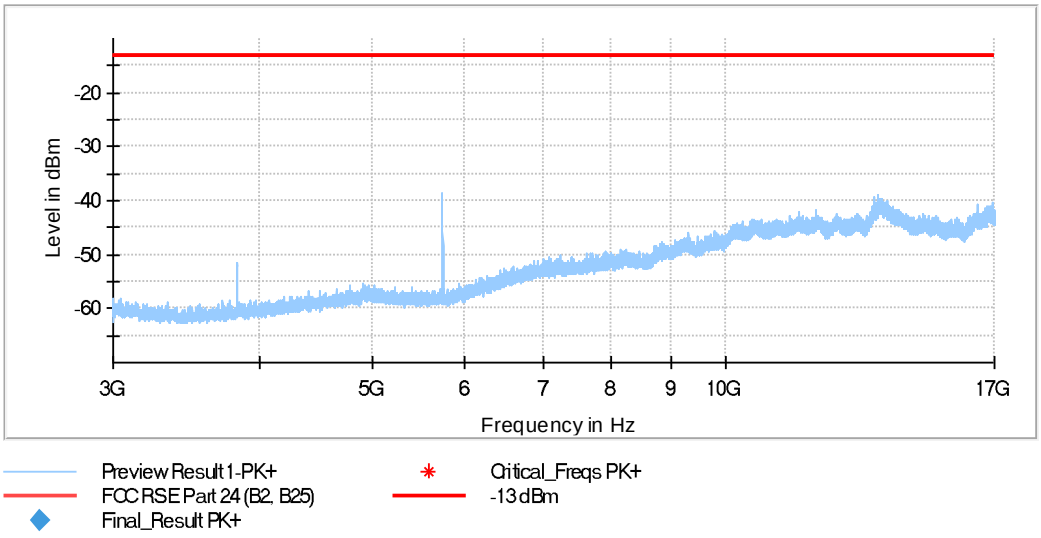

-20
-30
-40
-50
-60
Level in dBm
3G
5G
6
7
8
9
10G
17G
Frequency in Hz
Preview Result 1-PK+
FCC RSE Part 24 (B2, B25)
Final_Result PK+
Critical_Freqs PK+
-13 dBm

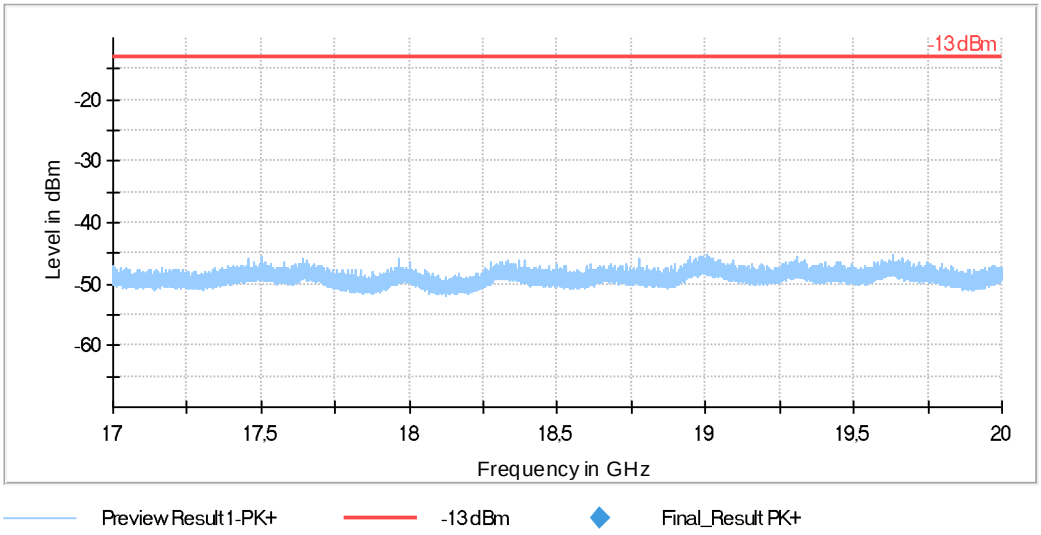

-13 dBm
-20
-30
-40
-50
-60
Level in dBm
17
17,5
18
18,5
19
19,5
20
Frequency in GHz
Preview Result 1-PK+
-13 dBm
Final_Result PK+

- High Channel:



The peak above the limit is the carrier frequency.




-13 dBm
-20
-30
-40
-50
-60
Level in dBm
17
17,5
18
18,5
19
19,5
20
Frequency in GHz
Preview Result 1-PK+
-13 dBm
Final_Result PK+

Appendix B: Test results for FCC 24 / RSS-133: LTE Cat NB2 Bands 2, 25

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TEST CONDITIONS

(*): Data provided by the Applicant.

POWER SUPPLY (*):

Vnormal:	3.8 Vdc.
Vminimum:	3
Vmaximum:	5.5 Vdc
Type of Power Supply:	Internal DC.

ANTENNA (*):

Bands	Gain (dBi)	Type
LTE Cat NB2 2	+3.0	SMD
LTE Cat NB2 25	+3.0	SMD

TEST FREQUENCIES:

LTE Cat NB2 Band 2. Pi/2-BPSK, Pi/4-QPSK, QPSK modulations:

Channel. Number (Frequency, MHz)		
Low	Middle	High
18602 (1850.2)*	18900 (1880)	19198 (1909.8)*
*The outermost channel which is in compliance with Block edge testing.		

NOTE: The LTE Cat NB2 Band 2 is completely included in the LTE Cat NB2 Band 25, so the channels of the LTE Cat NB2 Band 25 were tested to give conformity to the assigned block.

LTE Cat NB2 Band 25. Pi/2-BPSK, Pi/4-QPSK, QPSK modulations:

Channel (Frequency, MHz)		
Low	Middle	High
26042 (1850.2)*	26365 (1882.5)	26688 (1914.8)*
*The outermost channel which is in compliance with Block edge testing.		

RF Output Power

Limits

FCC §2.1046 and FCC §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. 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

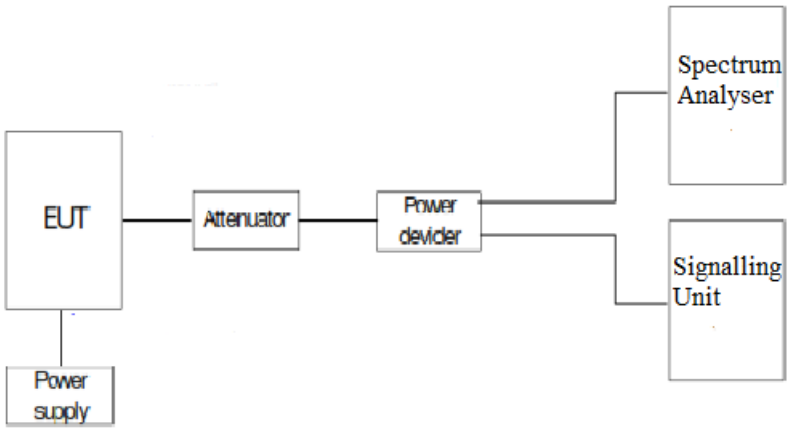
The conducted RF output power measurements were made at the RF output terminals of the EUT using the power meter of the Universal Radio Communication tester R&S CMW500. selecting maximum transmission power of the EUT and different modes of modulation.

The maximum equivalent isotropically radiated power (e.i.r.p.) is calculated by adding the declared maximum antenna gain (dBi).
The 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) and Conducted Average power:



Results

1. CONDUCTED AVERAGE POWER

LTE Cat NB2 Band 25:

Worst-case of RF Power is Low Channel, Pi/2-BPSK, BW=15 kHz, Tone Number=1, Tone Offset=0, MSC/TBS=0.

CHANNEL	FREQUENCY (MHz)	MODULATION	BW	Tone Number	Tone Offset (Start SubCarrier)	MCS / TBS	AVERAGE POWER (dBm)
Low 26042	1850.20 MHz	Pi/2-BPSK	3.75 kHz	1	0	0	22.52
				1	47	0	22.58
			15 kHz	1	0	0	22.63
				1	11	0	22.58
		Pi/4-QPSK	3.75 kHz	1	0	3	22.61
				1	47	3	22.55
			15 kHz	1	0	3	22.61
				1	11	3	22.56
		QPSK	15 kHz	3	0	5	22.32
				3	6	5	22.4
				6	0	5	21.47
				6	6	5	21.42
				12	0	5	20.53
Middle 26365	1882.50 MHz	Pi/2-BPSK	3.75 kHz	1	0	0	22.42
				1	47	0	22.39
			15 kHz	1	0	0	22.54
				1	11	0	22.48
		Pi/4-QPSK	3.75 kHz	1	0	3	22.55
				1	47	3	22.4
			15 kHz	1	0	3	22.58
				1	11	3	22.51
		QPSK	15 kHz	3	0	5	22.48
				3	6	5	22.6
				6	0	5	21.44
				6	6	5	21.54
				12	0	5	20.43
High 26688	1914.8 MHz	Pi/2-BPSK	3.75 kHz	1	0	0	22.49
				1	47	0	22.31
			15 kHz	1	0	0	22.61
				1	11	0	22.62
		Pi/4-QPSK	3.75 kHz	1	0	3	22.5
				1	47	3	22.41
			15 kHz	1	0	3	22.57
				1	11	3	22.57
		QPSK	15 kHz	3	0	5	22.51
				3	6	5	22.42
				6	0	5	21.34
				6	6	5	21.62
				12	0	5	20.48

MAX POWER	COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG. EIRP (dBm)	RAD. POWER AVG. ERP (dBm)
LOW	22.63	3	25.63	23.48
MIDDLE	22.6	3	25.6	23.45
HIGH	22.62	3	25.62	23.47
MAX:	22.63		25.63	

Measurement uncertainty (dB) <±0.941

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

LTE Cat NB2 Band 25:

Worst-case of PAPR is Low Channel, QPSK, BW=15 kHz, Tone Number=12, Tone Offset=0, MSC/TBS=5.

Low Channel: