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C.I.F. A29507456

ISED CABid: ES1909
Lab. Company Number: 4621A

Test Report No:
77535RRF.003A1

Test Report
USA FCC Part 27
CANADA RSS-Gen, RSS-130, RSS-139

(*) 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 27 (10-1-22 Edition). CANADA RSS-Gen Issue 5, April 2018, Amendment March 2019, Amendment February 2021. CANADA RSS-130 Issue 2, February 2019. CANADA RSS-139 Issue 4 September 2022, Amendment October 2022. 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"

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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/027_.1	nRF91	nRF9151	nRF9151 LACA CB0	1051275581	2024-01-08	Element Under Test
S/02	77535C/023_.1	SMA Cable	-		-	2024-01-08	Auxiliary Element
S/02	77535C/015_.1	USB Cable	-		-	2024-01-08	Auxiliary Element
S/03	77535C/026_.1	nRF91	nRF9151	nRF9151 LACA CB0	1051261483	2024-01-08	Element Under Test
S/03	77535C/012_.1	USB Cable	-		-	2023-12-15	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: The RF Output Power and PAPR tests of the LTE Cat-M1 Band 12 and Band 13.
S/02	Conducted tests: LTE Cat-M1 Band 12 and Band 13 but the RF Output Power and PAPR tests, and the LTE Cat-M1 Band 17 Block Edge tests.
S/03	Radiated tests.
S/04	Radiated test. Testing only in B85 Cat-M1.

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)	2024-01-18
Date (finish)	2024-02-22

Document history

Report number	Date	Description
77535RRF.003	2024-03-21	First release.
77535RRF.003A1	2024-04-04	Second release. Typos corrected about NB1 and NB2 references. This report replaces and cancels 77535RRF.003.

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: Antonio Maireles, Rafael Fernández, Pablo Redondo, Carmen Vázquez.

Used instrumentation:

Control No.	Equipment	Model	Manufacturer	Next Calibration
7760	Digital Multimeter	175	FLUKE	2024-11
6157	Signal and Spectrum Analyzer 10 Hz - 40 GHz	FSV40	ROHDE AND SCHWARZ	2025-01
9227	Wideband Radio Communication Tester	CMW500	ROHDE AND SCHWARZ	2024-07
6254	Attenuator 6 dB 2W DC-26.5 GHz	TWSMAG2	TECHNIWAVE	2024-03
6794	Shielded Room	S101	ETS LINDGREN	N/A
8002	TEMPERATURE CHAMBER MK56 BINDER	MK 56	BINDER	2024-04
6668	Signal and Spectrum Analyzer 10 Hz - 40 GHz	FSV40	ROHDE AND SCHWARZ	2024-12
9229	Wideband Radio Communication Tester	CMW500	ROHDE AND SCHWARZ	2024-06
8849	Wideband Radio Communication Tester	CMW500	ROHDE AND SCHWARZ	2025-10
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
3783	PRE-AMPLIFIER G>30dB 1GHz-18GHz	BLMA 0118-3A	BONN ELEKTRONIK	2025-02
6496	HORN ANTENNA 1-18 GHz	BBHA 9120 D	SCHWARZBECK	2026-12
8856	PRE-AMPLIFIER G>30dB 18-40GHz	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 4, 8, 12, 13, 66, 85.

FCC PART 27 / RSS-Gen, RSS-130, RSS-139		
Requirement – Test case	**Verdict**	**Remark**
FCC 27.50 / RSS-130 4.6, RSS-139 5.5: RF Output Power	P	
FCC 2.1047 / RSS-130 4.2, RSS-139 5.3: Modulation Characteristics	P	
FCC 27.54 / RSS-130 4.5, RSS-139 5.4: Frequency Stability	P	
FCC 2.1049 / RSS-Gen 6.7: Occupied Bandwidth	P	
FCC 27.53 / RSS-130 4.7, RSS-139 5.6: Spurious Emissions at Antenna Terminals	P	
FCC 27.53 / RSS-130 4.7, RSS-139 5.6: Spurious Emissions at Antenna Terminals at Block Edges	P	
FCC 27.53 / RSS-130 4.7, RSS-139 5.6: Radiated Emissions	P	
Supplementary information and remarks: None.		

Appendix B: LTE Cat NB2 Bands 4, 8, 12, 13, 17, 66, 85.

FCC PART 27 / RSS-Gen, RSS-130, RSS-139		
Requirement – Test case	**Verdict**	**Remark**
FCC 27.50 / RSS-130 4.6, RSS-139 5.5: RF Output Power	P	
FCC 2.1047 / RSS-130 4.2, RSS-139 5.3: Modulation Characteristics	P	
FCC 27.54 / RSS-130 4.5, RSS-139 5.4: Frequency Stability	P	
FCC 2.1049 / RSS-Gen 6.7: Occupied Bandwidth	P	
FCC 27.53 / RSS-130 4.7, RSS-139 5.6: Spurious Emissions at Antenna Terminals	P	
FCC 27.53 / RSS-130 4.7, RSS-139 5.6: Spurious Emissions at Antenna Terminals at Block Edges	P	
FCC 27.53 / RSS-130 4.7, RSS-139 5.6: Radiated Emissions	P	
Supplementary information and remarks: None.		

Appendix A: Test results for FCC 27 / RSS-130, RSS-139: LTE Cat-M1 Bands 4, 8, 12, 13, 66, 85

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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 (*):

Low Bands	Gain (dBi)	Type of Antenna
LTE Cat-M1 8	+2.70	SMD
LTE Cat-M1 12	+1.56	SMD
LTE Cat-M1 13	+1.56	SMD
LTE Cat-M1 85	+1.56	SMD
High Bands	Gain (dBi)	Type
LTE Cat-M1 4	+3.0	SMD
LTE Cat-M1 66	+3.0	SMD

TEST FREQUENCIES:

LTE Cat-M1 Band 4. QPSK and 16QAM modulations:

	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	19957 (1710.7)	19965 (1711.5)	19975 (1712.5)	20000 (1715.0)	20025 (1717.5)	20050 (1720.0)
Middle	20175 (1732.5)	20175 (1732.5)	20175 (1732.5)	20175 (1732.5)	20175 (1732.5)	20175 (1732.5)
High	20393 (1754.3)	20385 (1753.5)	20375 (1752.5)	20350 (1750.0)	20325 (1747.5)	20300 (1745.0)

NOTE: LTE Cat-M1 Band 4 is completely included in LTE Cat-M1 Band 66, so the channels of LTE Cat-M1 Band 66 were tested to give conformity to the assigned block.

LTE Cat-M1 Band 8. QPSK and 16QAM modulations:

	Channel (Frequency, MHz)	
	BW = 1.4 MHz	BW = 3 MHz
Low	21632 (898.2)	
Middle		21640 (899)
High	21648 (899.8)	

LTE Cat-M1 Band 12. QPSK and 16QAM modulations:

	Channel (Frequency, MHz)			
	BW = 1.4 MHz	BW = 3 MHz	BW = 5 MHz	BW = 10 MHz
Low	23017 (699.7)	23025 (700.5)	23035 (701.5)	23060 (704.0)
Middle	23095 (707.5)	23095 (707.5)	23095 (707.5)	23095 (707.5)
High	23173 (715.3)	23165 (714.5)	23155 (713.5)	23130 (711.0)

NOTE: LTE Cat-M1 Band 12 is completely included in LTE Cat-M1 Band 85, so the channels of LTE Cat-M1 Band 85 were tested to give conformity to the assigned block, but for the Block Edge test, where only the Low Channel was tested for 85.

LTE Cat-M1 Band 13. QPSK and 16QAM modulations:

	Channel (Frequency, MHz)	
	BW = 5 MHz	BW = 10 MHz
Low	23205 (779.5)	
Middle	23230 (782.0)	23230 (782.0)
High	23255 (784.5)	

LTE Cat-M1 Band 66. QPSK and 16QAM modulations:

	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	131979 (1710.7)	131987 (1711.5)	131997 (1712.5)	132022 (1715.0)	132047 (1717.5)	132072 (1720.0)
Middle	132322 (1745)	132322 (1745)	132322 (1745)	132322 (1745)	132322 (1745)	132322 (1745)
High	132665 (1779.3)	132657 (1778.5)	132647 (1777.5)	132622 (1775)	132597 (1772.5)	132572 (1770)

LTE Cat-M1 Band 85. QPSK and 16QAM modulations:

	Channel (Frequency)	
	BW = 5 MHz	BW = 10 MHz
Low	134027 (700.5)	134052 (703.0)
Middle	134092 (707)	134092 (707)
High	134157 (713.5)	134132 (711.0)

RF Output Power

Limits

1. LTE Cat-M1 Band 8. FCC §27.1507 (a) & (d).

FCC §27.1507 (a) & (d):

(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.

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

(4) *Portable stations*. Portable stations must not exceed 3 watts ERP.

(d) *PAR limit*. The peak-to-average ratio (PAR) of the transmission must not exceed 13 dB.

2. LTE Cat-M1 Band 13. FCC §27.50 (b) (10) / RSS-130 Clause 4.6.

FCC §27.50 (b) (10):

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

RSS-130 4.6:

4.6.1 General

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

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

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

3. LTE Cat-M1 Band 66. FCC §27.50 (d) / RSS-139 5.5.

FCC §27.50 (d):

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

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

RSS-139 5.5:

The maximum output power of the equipment shall comply with the limits specified below. In the tables, maximum power refers to the equivalent isotropically radiated power (e.i.r.p.) or total radiated power (TRP), measured in terms of average values.

The limits in this RSS are specified for the purpose of certification and may not apply to all deployment scenarios. Consult SRSP-513 and SRSP-519 for more details on the bands 2110-2180 MHz and 2180-2200 MHz respectively.

Table 3: Maximum power of equipment in the band 1710-1780 MHz	
Equipment type	**Maximum power**
Fixed station and base station	30 dBm e.i.r.p./channel bandwidth
Subscriber equipment	30 dBm e.i.r.p./channel bandwidth

Table 4: Maximum power of equipment in the band 2110-2180 MHz	
Equipment type	**Maximum power**
Non-AAS fixed station and base station	65 dBm e.i.r.p./MHz
AAS fixed station and base station	46 dBm TRP/MHz
Subscriber equipment	30 dBm e.i.r.p./channel bandwidth

Table 5: Maximum power of equipment in the band 2180-2200 MHz	
Equipment type	**Maximum power**
Non-AAS base station	65 dBm e.i.r.p./MHz
AAS base station	46 dBm TRP/MHz

In addition, the peak to average power ratio (PAPR) of the equipment shall not exceed 13 dB for more than 0.1% of the time, using a signal that corresponds to the highest PAPR during periods of continuous transmission.

4. LTE Cat-M1 Band 12, 85. FCC §27.50 (c) (10) / RSS-130 Clause 4.6.

FCC §27.50 (c) (10):

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

RSS-130 Clause 4.6:

> 4.6.1 General
>
> The transmitter output power shall be measured in terms of average power. In addition, the peak-to-average power ratio (PAPR) of the transmitter shall not exceed 13 dB for more than 0.1% of the time and shall use a signal corresponding to the High PAPR during periods of continuous transmission.
>
> 4.6.3 Frequency bands 698-756 MHz and 777-787 MHz
>
> The e.r.p. shall not exceed 30 watts for mobile equipment and outdoor fixed subscriber equipment. The e.r.p. shall not exceed 3 watts for portable equipment and indoor fixed subscriber equipment.

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).

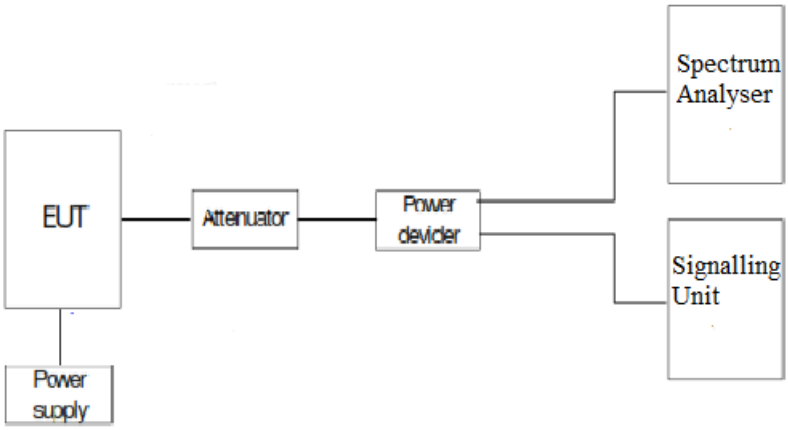
The maximum effective radiated power e.r.p. is calculated from the maximum equivalent isotropically radiated power (e.i.r.p.) by subtracting 2.15 dB:

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

Test Setup

1. CONDUCTED AVERAGE POWER:

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



Results

1. CONDUCTED AVERAGE POWER:

LTE Cat-M1 Band 8:

Worst-case of RF Power is BW=1.4 MHz, High Channel, QPSK, RB Size=1, RB Offset=2, Narrowband=0.

BANDWIDTH (MHz)	CHANNEL	FREQUENCY (MHz)	MODULATION	RB SIZE	RB OFFSET	AVERAGE POWER (dBm)
1.4	Low 21632	898.2	QPSK	1	0	22.77
				1	2	22.81
				1	5	22.77
				3	0	21.75
				3	1	21.71
				3	3	21.75
				6	0	21.93
			16QAM	1	0	22.51
				1	2	22.61
				1	5	22.66
				3	0	21.52
				3	1	21.58
				3	3	21.53
				5	0	20.45
	High 21648	899.8	QPSK	1	0	22.8
				1	2	22.92
				1	5	22.8
				3	0	21.78
				3	1	21.74
				3	3	21.77
				6	0	20.08
			16QAM	1	0	22.56
				1	2	22.56
				1	5	22.55
				3	0	21.56
				3	1	21.52
				3	3	21.56
				5	0	20.49

BW=1.4 MHz. QPSK:

MAX POWER	QPSK COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG EIRP (dBm)	RAD. POWER AVG ERP (dBm)
LOW	22.81	2.7	25.51	23.36
MIDDLE				
HIGH	22.92	2.7	25.62	23.47
MAX:	22.92		25.62	23.47

BW=1.4 MHz. 16QAM:

MAX POWER	16QAM COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG EIRP (dBm)	RAD. POWER AVG ERP (dBm)
LOW	22.66	2.7	25.36	23.21
MIDDLE				
HIGH	22.56	2.7	25.26	23.11
MAX:	22.66		25.36	23.21

LTE Cat-M1 Band 13:

Worst-case of RF Power is BW=5 MHz. High Channel. QPSK. RB Size=1. RB Offset=0. Narrowband=0.

BANDWIDTH (MHz)	CHANNEL	FREQUENCY (MHz)	MODULATION	RB SIZE	RB OFFSET	AVERAGE POWER (dBm)
5	Low 23205	779.5	QPSK	1	0	22.11
				1	2	22.11
				1	5	22.11
				3	0	21.11
				3	1	21.11
				3	3	21.10
				6	0	21.20
			16QAM	1	0	21.55
				1	2	21.39
				1	5	21.41
				3	0	20.89
				3	1	20.88
				3	3	20.89
				5	0	20.01
	High 23255	784.5	QPSK	1	0	22.14
				1	2	22.13
				1	5	22.14
				3	0	21.23
				3	1	21.24
				3	3	21.22
				6	0	21.25
			16QAM	1	0	22.06
				1	2	22.05
				1	5	22.06
				3	0	20.98
				3	1	20.99
				3	3	21
				5	0	20

BW=5 MHz. QPSK:

MAX POWER	QPSK COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG EIRP (dBm)	RAD. POWER AVG ERP (dBm)
LOW	22.11	1.56	23.67	21.52
MIDDLE				
HIGH	22.14	1.56	23.7	21.55
MAX:	22.14		23.7	21.55

BW=5 MHz. 16QAM:

MAX POWER	16QAM COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG EIRP (dBm)	RAD. POWER AVG ERP (dBm)
LOW	21.55	1.56	23.11	20.96
MIDDLE				
HIGH	22.06	1.56	23.62	21.47
MAX:	22.06		23.62	21.47

LTE Cat-M1 Band 66:

Worst-case of RF Power is BW=15 MHz. Low Channel. QPSK. RB Size=6. RB Offset=0. Narrowband=0.

BANDWIDTH (MHz)	CHANNEL	FREQUENCY (MHz)	MODULATION	RB SIZE	RB OFFSET	AVERAGE POWER (dBm)
15	Low 132047	1717.5	QPSK	1	0	22.68
				1	2	22.81
				1	5	22.68
				3	0	22.74
				3	1	22.71
				3	3	22.75
				6	0	22.87
			16QAM	1	0	22.78
				1	2	22.83
				1	5	22.79
				3	0	22.83
				3	1	22.8
				3	3	22.78
				5	0	22.69
	Middle 132322	1745	QPSK	1	0	22.55
				1	2	22.64
				1	5	22.57
				3	0	22.48
				3	1	22.45
				3	3	22.5
				6	0	22.6
			16QAM	1	0	22.5
				1	2	22.53
				1	5	22.4
				3	0	22.67
				3	1	22.66
				3	3	22.6
				5	0	22.5
	High 132597	1772.5	QPSK	1	0	22.71
				1	2	22.83
				1	5	22.69
				3	0	22.8
				3	1	22.66
				3	3	22.8
				6	0	22.7
			16QAM	1	0	22.3
				1	2	22.44
				1	5	22.17
				3	0	22.58
				3	1	22.79
				3	3	22.55
				5	0	22.67

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	22.87	3	25.87	23.72
MIDDLE	22.64	3	25.64	23.49
HIGH	22.83	3	25.83	23.68
MAX:	22.87		25.87	23.72

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	22.83	3	25.83	23.68
MIDDLE	22.67	3	25.67	23.52
HIGH	22.79	3	25.79	23.64
MAX:	22.83		25.83	23.68

LTE Cat-M1 Band 85:

Worst-case of RF Power is BW=5 MHz. High Channel. QPSK. RB Size=1. RB Offset=2. Narrowband=1.

BANDWIDTH (MHz)	CHANNEL	FREQUENCY (MHz)	MODULATION	RB SIZE	RB OFFSET	AVERAGE POWER (dBm)
5	Low 134027	700.5	QPSK	1	0	22.81
				1	2	22.87
				1	5	22.74
				3	0	21.76
				3	1	21.73
				3	3	21.88
				6	0	22
			16QAM	1	0	22.57
				1	2	22.56
				1	5	22.57
				3	0	21.53
				3	1	21.58
				3	3	21.61
				5	0	20.47
	Middle 134092	707	QPSK	1	0	22.71
				1	2	22.85
				1	5	22.72
				3	0	21.76
				3	1	21.73
				3	3	21.77
				6	0	21.92
			16QAM	1	0	22.66
				1	2	22.61
				1	5	22.55
				3	0	21.51
				3	1	21.58
				3	3	21.63
				5	0	20.44
	High 134157	713.5	QPSK	1	0	22.8
				1	2	23.01
				1	5	22.85
				3	0	22.01
				3	1	21.97
				3	3	21.99
				6	0	21.92
			16QAM	1	0	22.38
				1	2	22.52
				1	5	22.41
				3	0	21.68
				3	1	21.59
				3	3	21.65
				5	0	20.53

BW=5 MHz. QPSK:

MAX POWER	QPSK COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG EIRP (dBm)	RAD. POWER AVG ERP (dBm)
LOW	22.87	1.56	24.43	22.28
MIDDLE	22.85	1.56	24.41	22.26
HIGH	23.01	1.56	24.57	22.42
MAX:	23.01		24.57	22.42

BW=5 MHz. 16QAM:

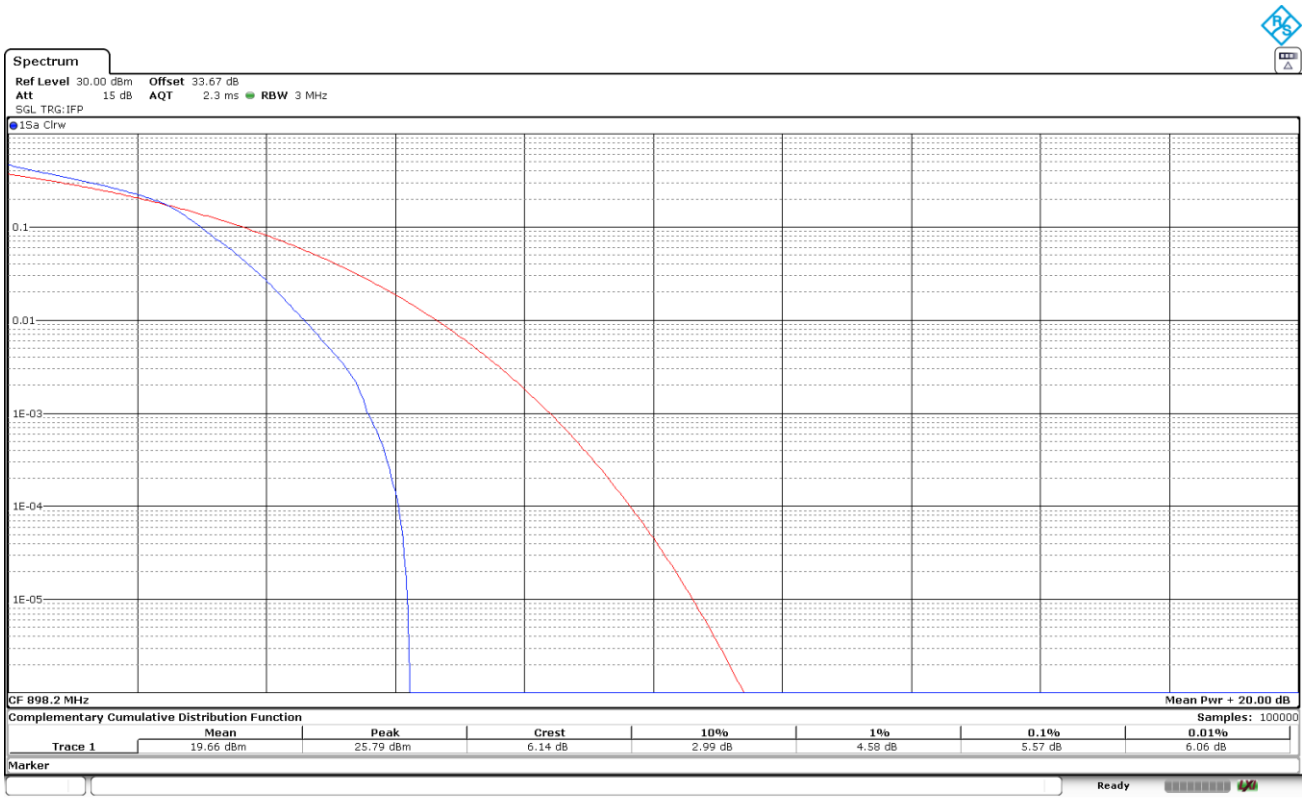
MAX POWER	16QAM COND. POWER AVG (dBm)	ANTENNA GAIN (dBi)	RAD. POWER AVG EIRP (dBm)	RAD. POWER AVG ERP (dBm)
LOW	22.57	1.56	24.13	21.98
MIDDLE	22.66	1.56	24.22	22.07
HIGH	22.52	1.56	24.08	21.93
MAX:	22.66		24.22	22.07

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

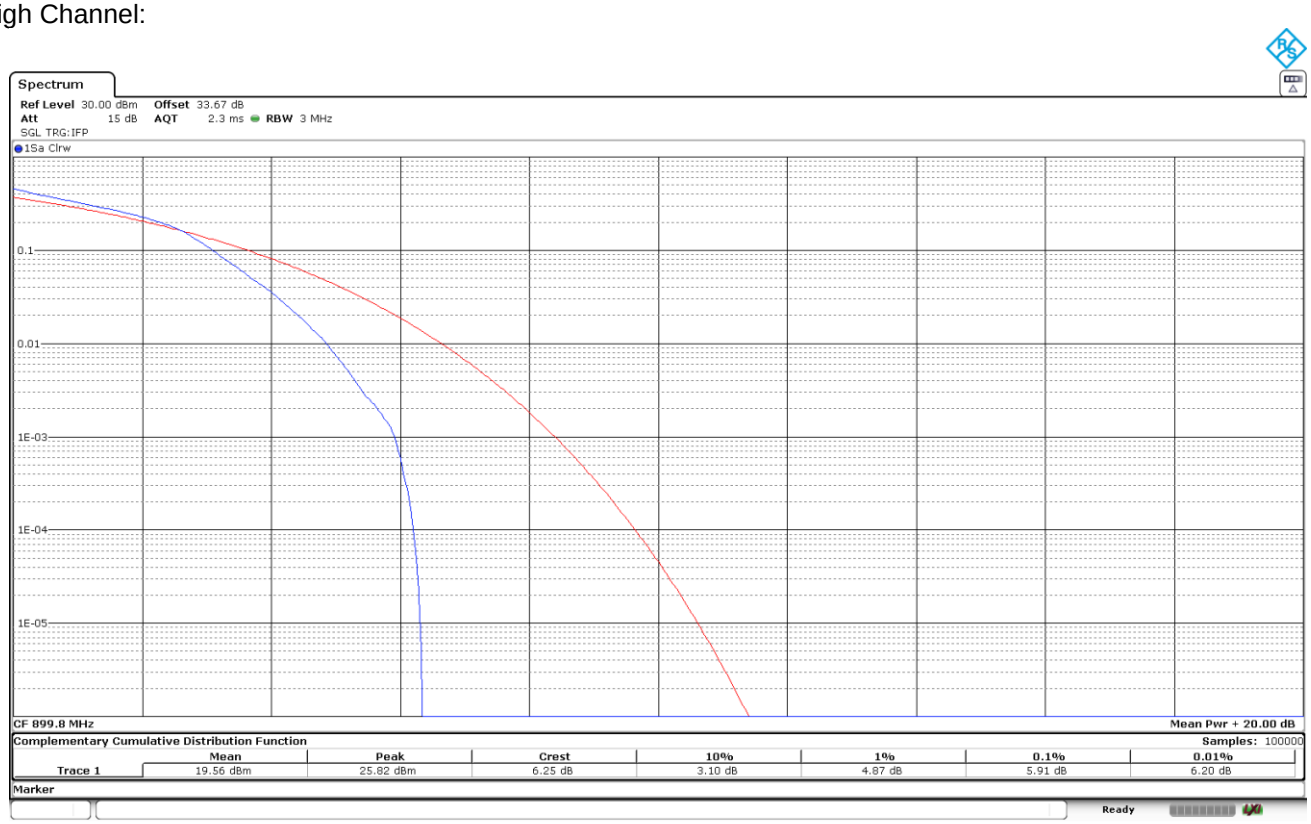
LTE Cat-M1 Band 8:

Worst-case of PAPR is BW=1.4 MHz. High Channel. 16QAM. RB Size=5. RB Offset=0. Narrowband=0.

Low Channel:



High Channel:



16QAM	Low	High
PAPR (dB)	5.57	5.91

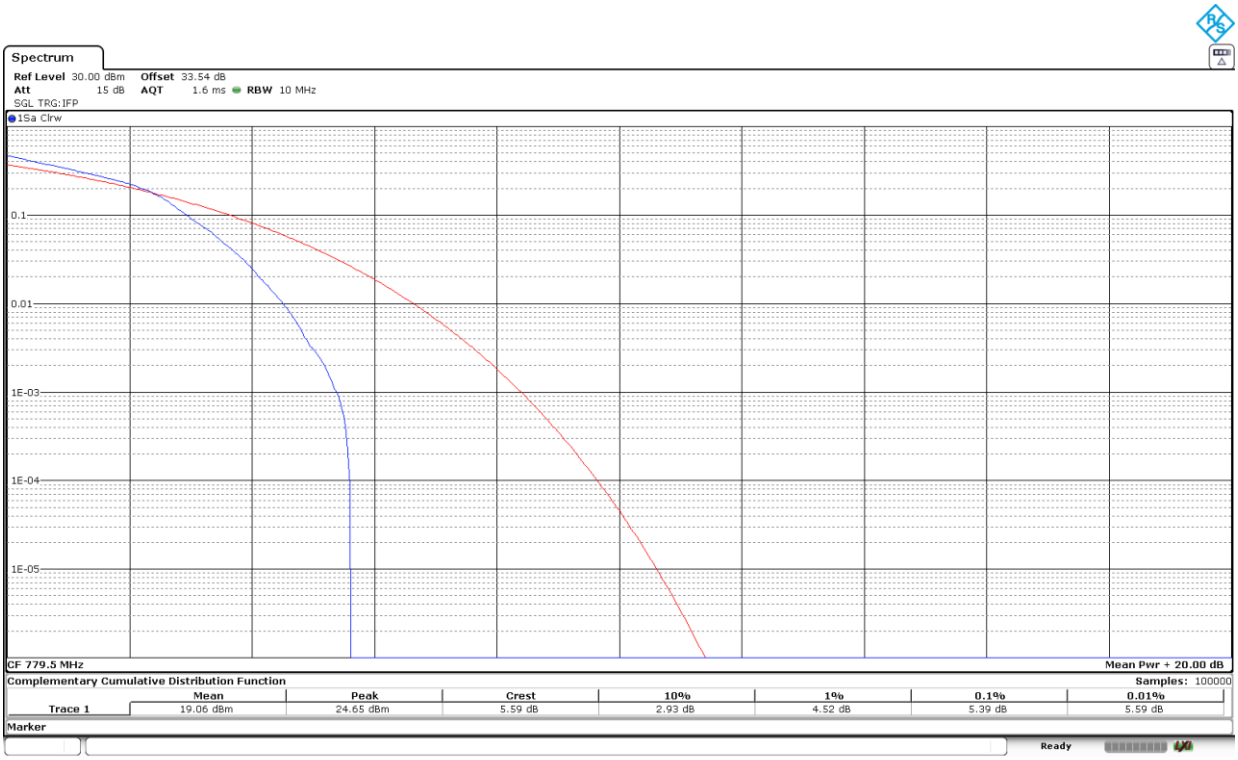
Verdict

Pass

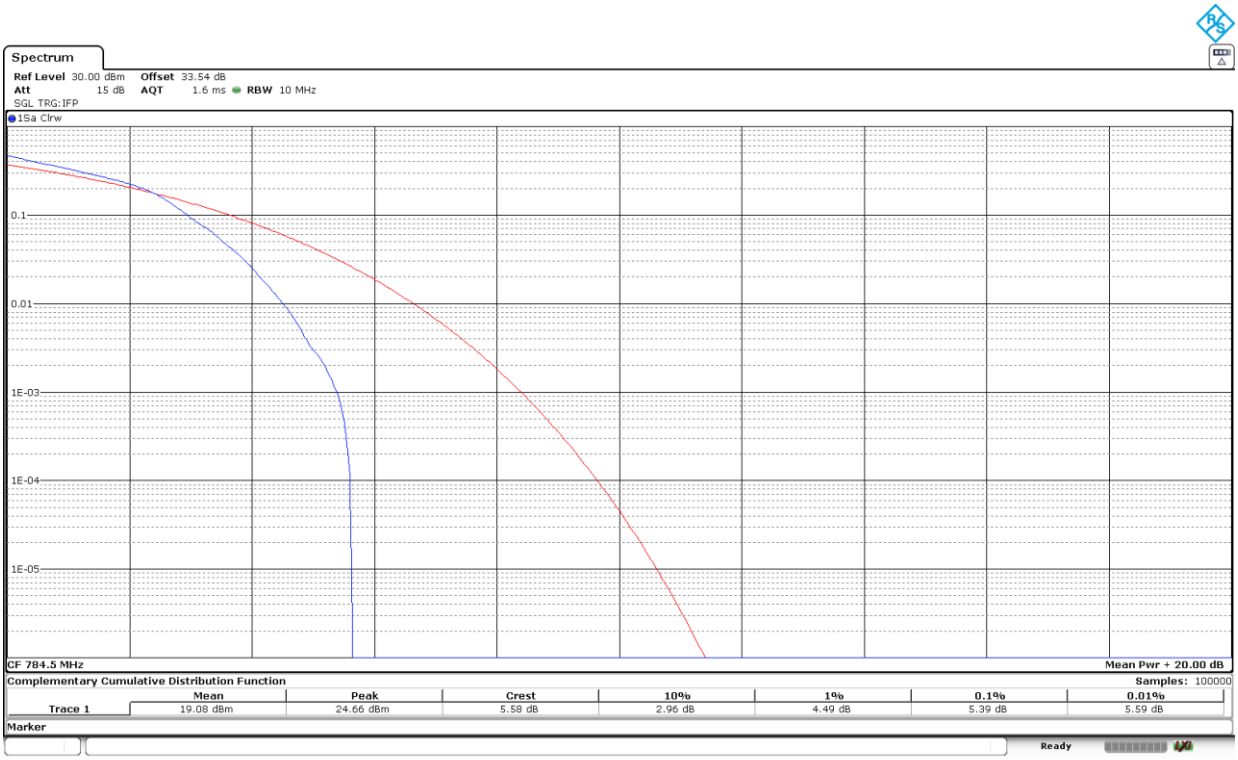
LTE Cat-M1 Band 13:

Worst-case of PAPR is BW= 5 MHz. Low Channel. 16QAM. RB Size=5. RB Offset=0. Narrowband=0.

Low Channel:



High Channel:



16QAM	Low	High
PAPR (dB)	5.39	5.39

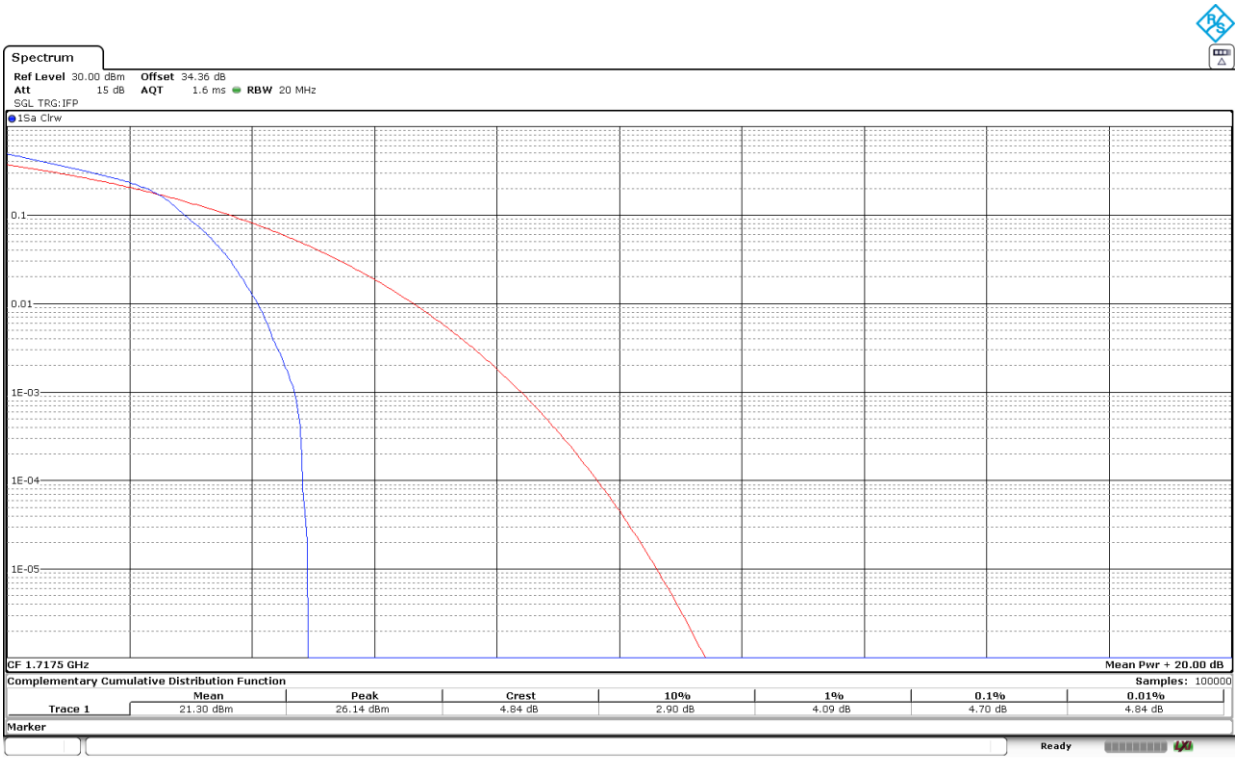
Verdict

Pass

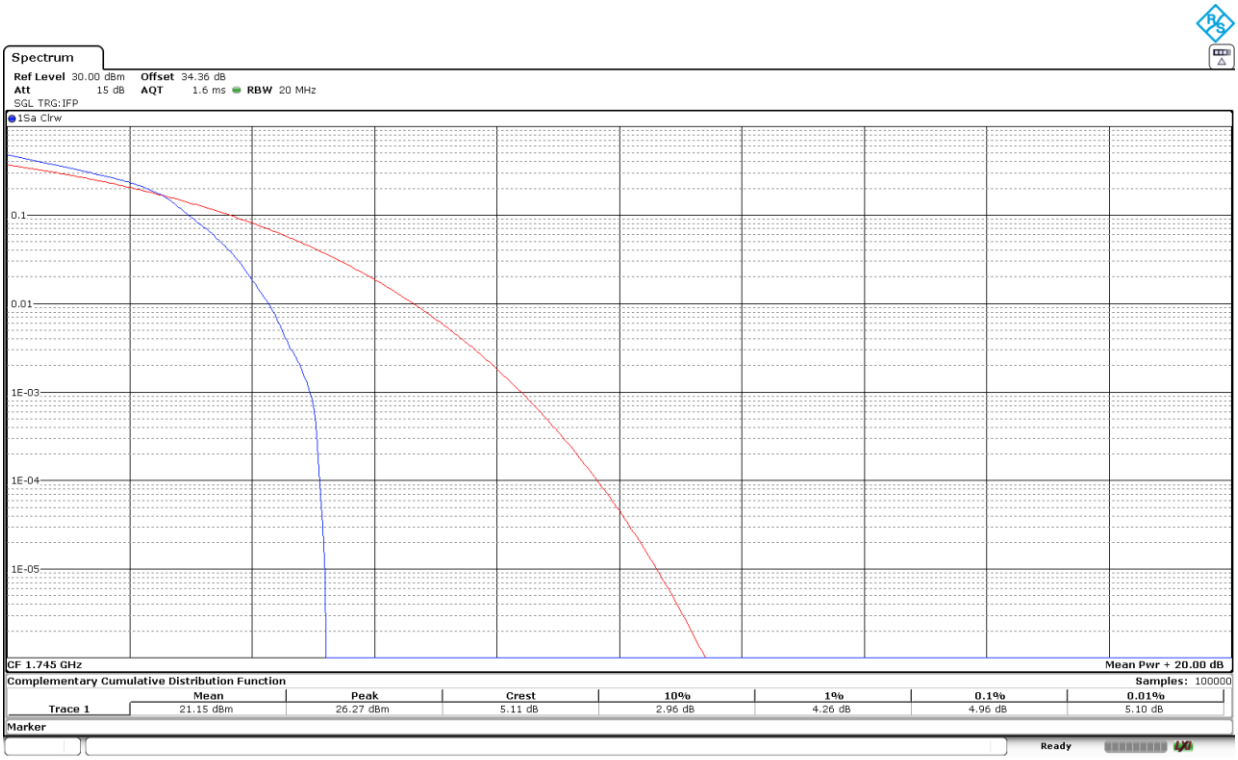
LTE Cat-M1 Band 66:

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

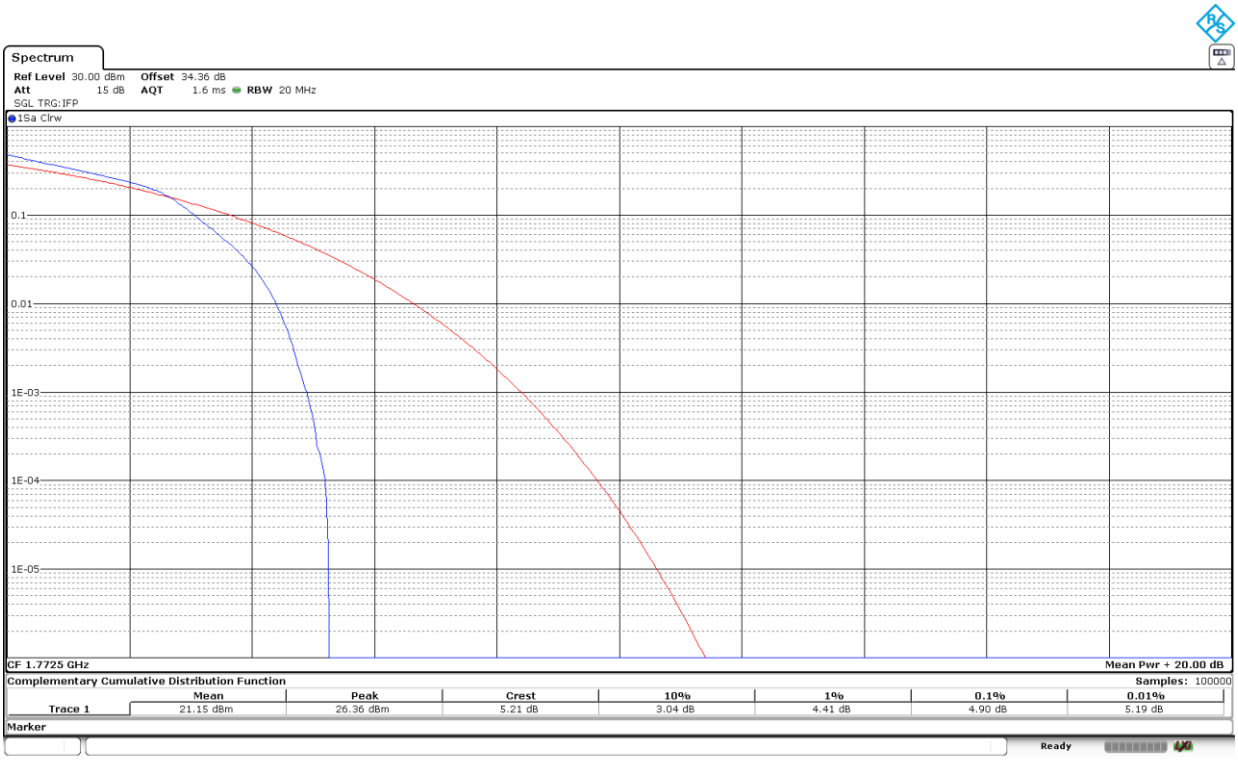
Low Channel:



Middle Channel:



High Channel:



16QAM	Low	Middle	High
PAPR (dB)	4.7	4.96	4.9

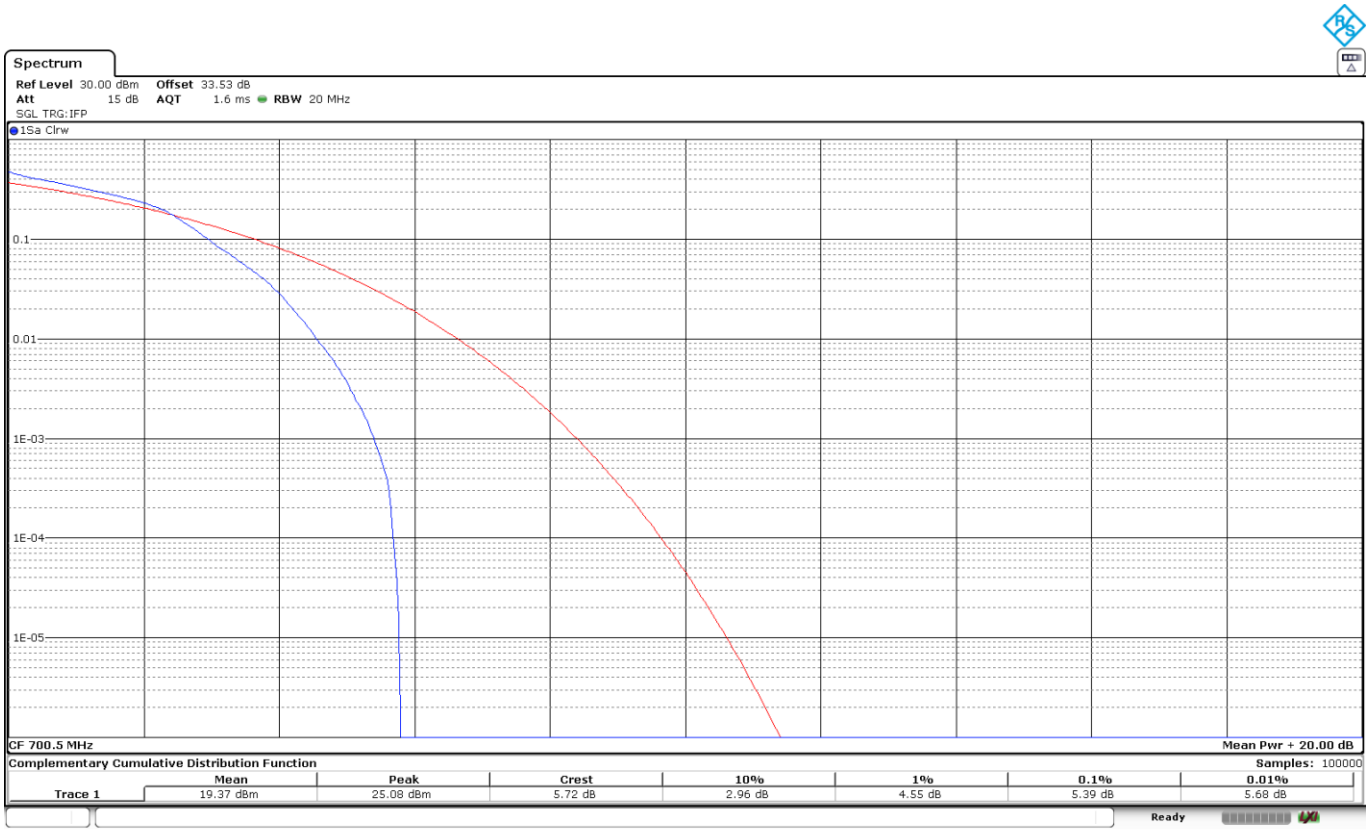
Verdict

Pass

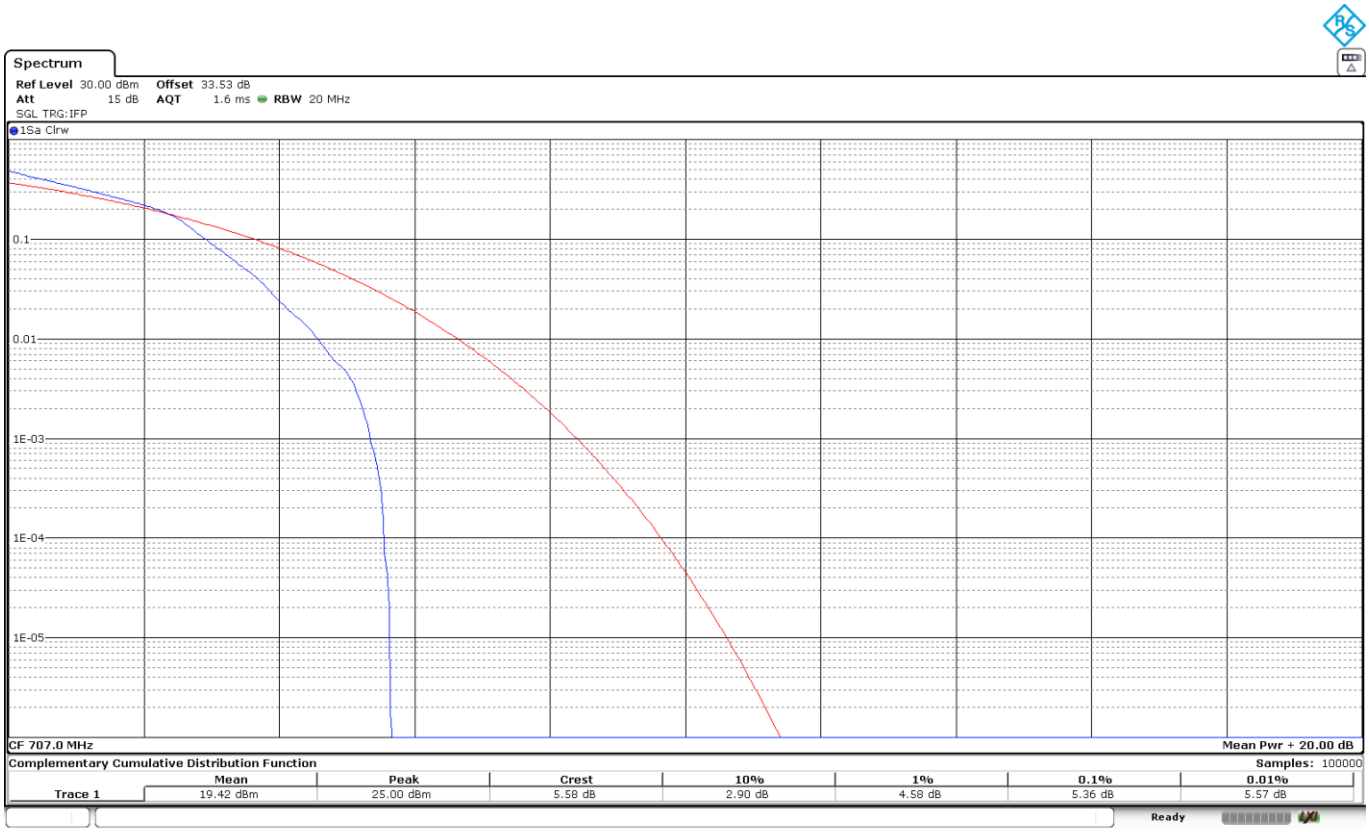
LTE Cat-M1 Band 85:

Worst-case of PAPR is BW=5 MHz. High Channel. 16QAM. RB Size=5. RB Offset=0. Narrowband=1.

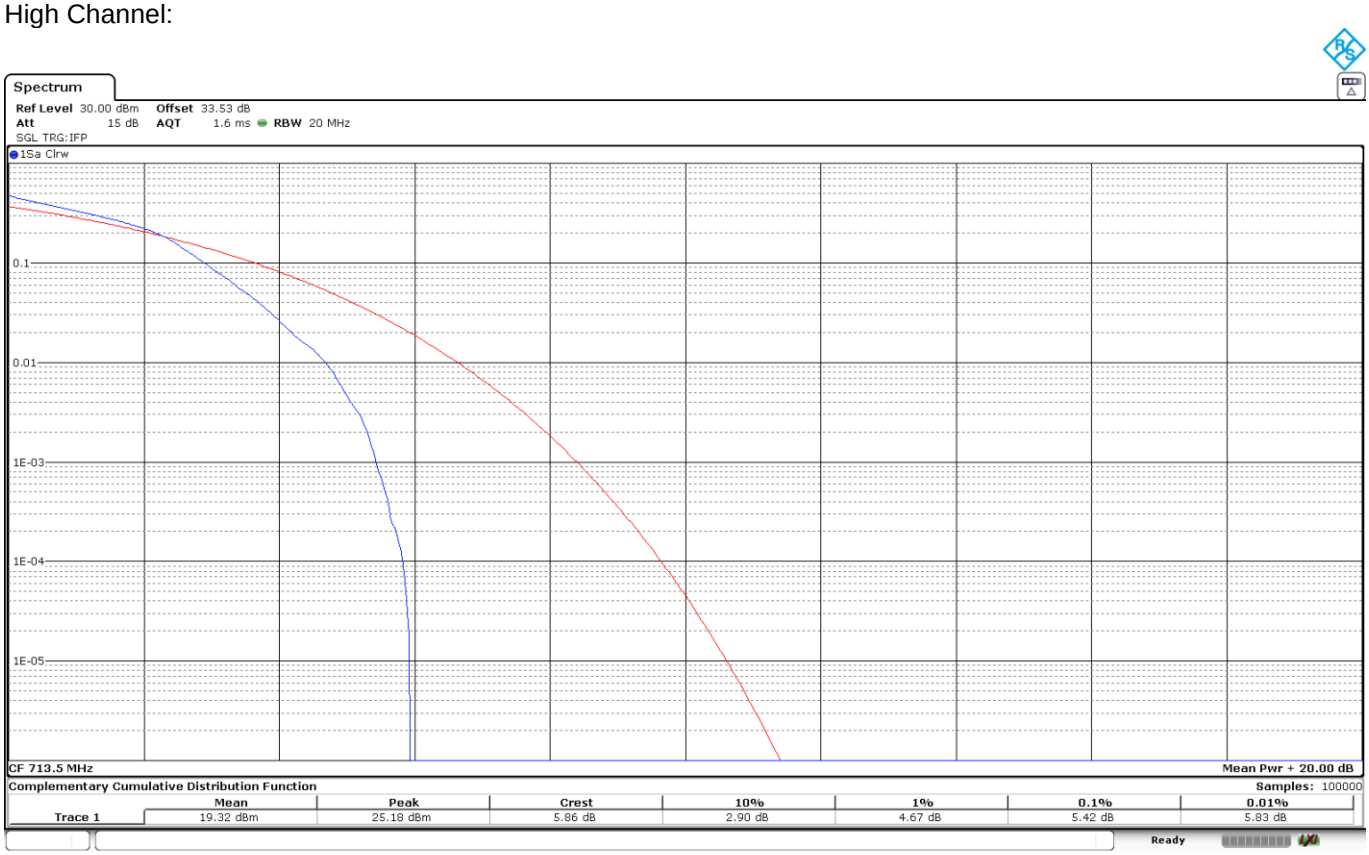
Low Channel:



Middle Channel:



High Channel:



16QAM	Low	Middle	High
PAPR (dB)	5.39	5.36	5.42

Verdict

Pass

Frequency Stability

Limits

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

* RSS-130. Clause 4.5 & RSS-139. 5.4. The frequency stability shall be sufficient to ensure that the occupied bandwidth stays within the operating frequency block or frequency block group when tested to the temperature and supply voltage variations specified in RSS-Gen.

Method

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

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

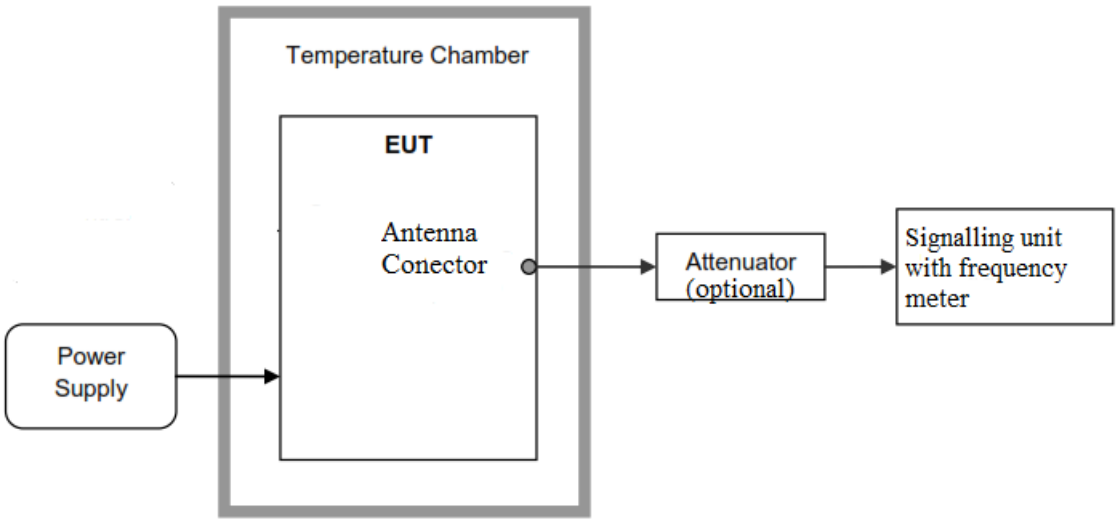
The EUT was set in “Radio Resource Control (RRC) mode” on the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case LTE mode for conducted power was used for the test.

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 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.

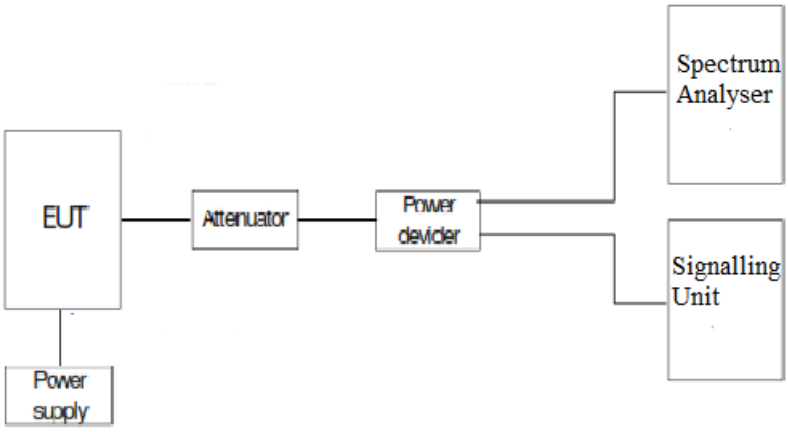
The reference point measurements were made at the RF output terminals of the EUT using an attenuator. power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

Test Setup

Frequency tolerance:



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



Results

1. FREQUENCY TOLERANCE:

- **Frequency stability over temperature variations:**

LTE Cat-M1 Band 8:

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

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+85	-2.55	-0.002836485
+80	-4.1	-0.004560623
+70	5.42	0.006028921
+60	-0.58	-0.000645161
+50	0.72	0.00080089
+40	-0.92	-0.001023359
+30	-0.56	-0.000622914
+20	-6.63	-0.007374861
+10	4.03	0.004482759
0	3.43	0.00381535
-10	-5.25	-0.005839822
-20	-0.52	-0.00057842
-30	-2.03	-0.002258065
-40	-0.13	-0.000144605

LTE Cat-M1 Band 13:

The worst case modulation in terms of Frequency Stability is BW=5 MHz. QPSK.

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
85	-1.43	-0.001828645
80	-3.23	-0.004130435
70	-4.42	-0.005652174
60	2	0.002557545
+50	-6.1	-0.007800512
+40	-1.16	-0.001483376
+30	-7.71	-0.009859335
+20	-4.59	-0.005869565
+10	-6.78	-0.008670077
0	-4.18	-0.005345269
-10	-1.44	-0.001841432
-20	5.71	0.00730179
-30	-8.72	-0.011150895
-40	-5.67	-0.007250639

LTE Cat-M1 Band 66:

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

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+85	1.5	0.000859599
+80	3.58	0.002051576
+70	1.77	0.001014327
+60	6.82	0.003908309
+50	2.61	0.001495702
+40	1.63	0.000934097
+30	-0.41	-0.000234957
+20	0.24	0.000137536
+10	0.83	0.000475645
0	-1.56	-0.000893983
-10	3.53	0.002022923
-20	0.93	0.000532951
-30	0.37	0.000212034
-40	-0.15	-8.59599E-05

LTE Cat-M1 Band 85:

The worst case modulation in terms of Frequency Stability is BW=5 MHz. QPSK.

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+85	2.86	0.004045262
+80	5.14	0.007270156
+70	3.69	0.005219236
+60	2.85	0.004031117
+50	5.94	0.008401697
+40	5.25	0.007425743
+30	3.86	0.005459689
+20	4.56	0.006449788
+10	-6.58	-0.009306931
0	1.53	0.002164074
-10	0.94	0.001329562
-20	1.59	0.002248939
-30	-2.56	-0.003620934
-40	3.34	0.004724187

- **Frequency stability over voltage variations:**

LTE Cat-M1 Band 8:

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

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	-5.93	-0.006596218
Vmin	3	3.43	0.00381535

LTE Cat-M1 Band 13:

The worst case modulation in terms of Frequency Stability is BW=5 MHz. QPSK.

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	-3.19	-0.004079284
Vmin	3	-4.52	-0.005780051

LTE Cat-M1 Band 66:

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

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	-2.7	-0.001547278
Vmin	3	-1.07	-0.000613181

LTE Cat-M1 Band 85:

The worst case modulation in terms of Frequency Stability is BW=5 MHz. QPSK.

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	-0.53	-0.000749646
Vmin	3	0.2	0.000282885

2. REFERENCE FREQUENCY POINTS fL AND fH:

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

LTE Cat-M1 Band 4: BW=1.4 MHz. QPSK.

*f*L (MHz)	1710.0205
*f*H (MHz)	1754.9640

LTE Cat-M1 Band 8: BW=1.4 MHz. QPSK.

*f*L (MHz)	897.5436
*f*H (MHz)	900.4520

LTE Cat-M1 Band 12: BW=1.4 MHz. QPSK.

*f*L (MHz)	699.0171
*f*H (MHz)	715.9734

LTE Cat-M1 Band 13: BW=5 MHz. QPSK.

*f*L (MHz)	777.1115
*f*H (MHz)	786.8845

LTE Cat-M1 Band 66: BW=1.4 MHz. QPSK.

*f*L (MHz)	1710.0205
*f*H (MHz)	1779.9669

LTE Cat-M1 Band 85: BW=5 MHz. QPSK.

*f*L (MHz)	698.1129
*f*H (MHz)	715.9734

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

Measurement uncertainty (Hz): <±207.77

Verdict

PASS

Modulation Characteristics

Limits

FCC §2.1047.

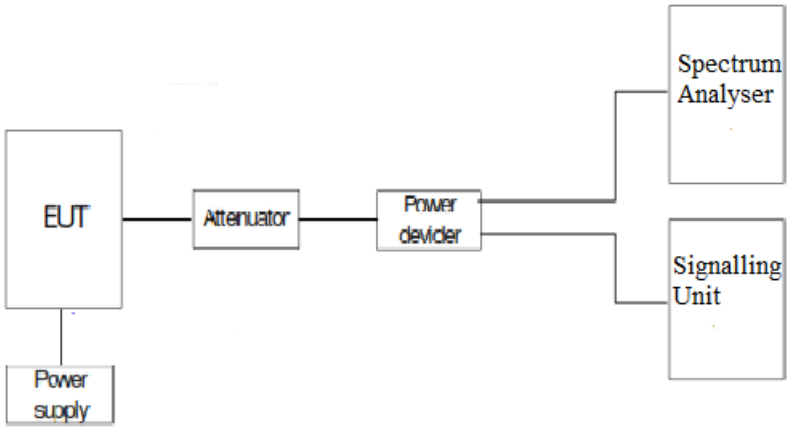
RSS-130. 4.2: Equipment certified under this standard shall employ digital modulation.

RSS-139. 5.3: Devices may use any type of modulation technique. The type of modulation shall be documented in the test report.

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

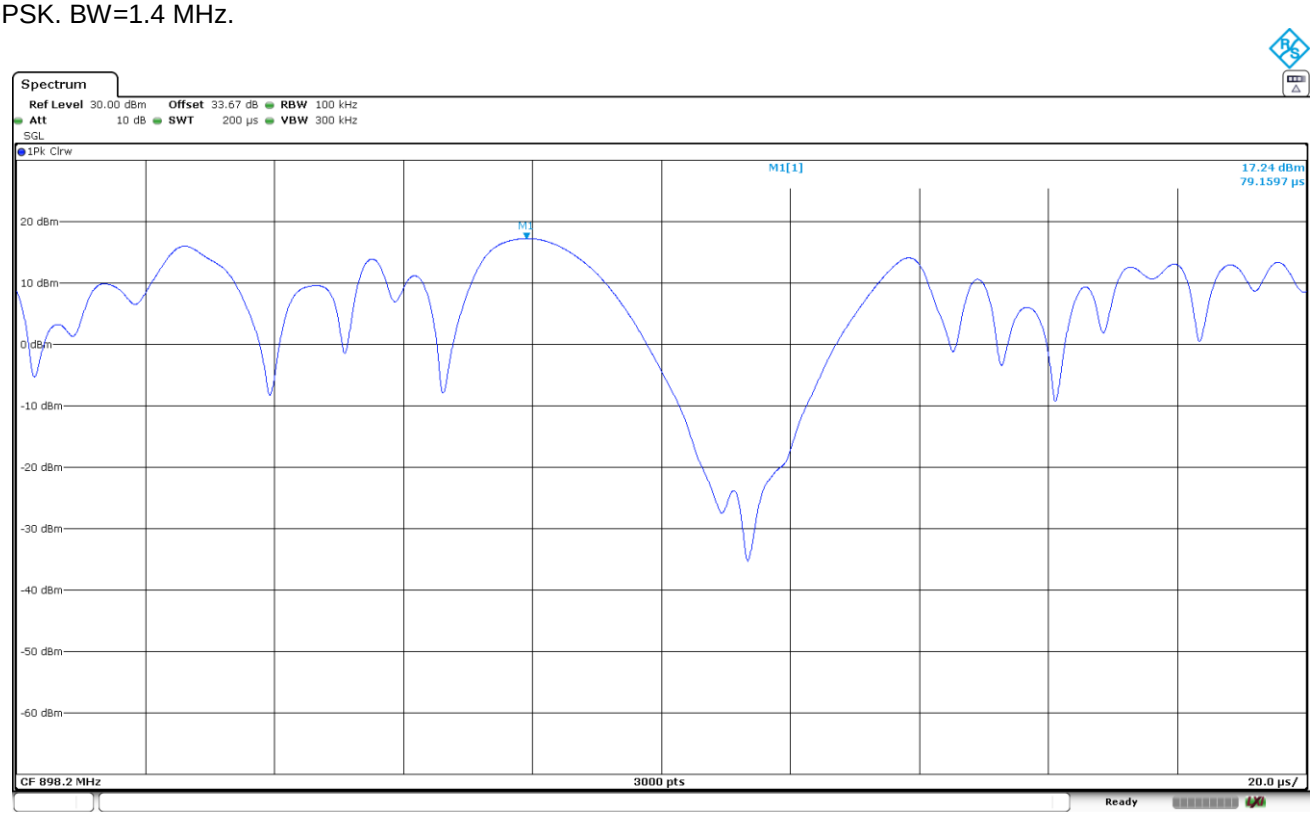


Results

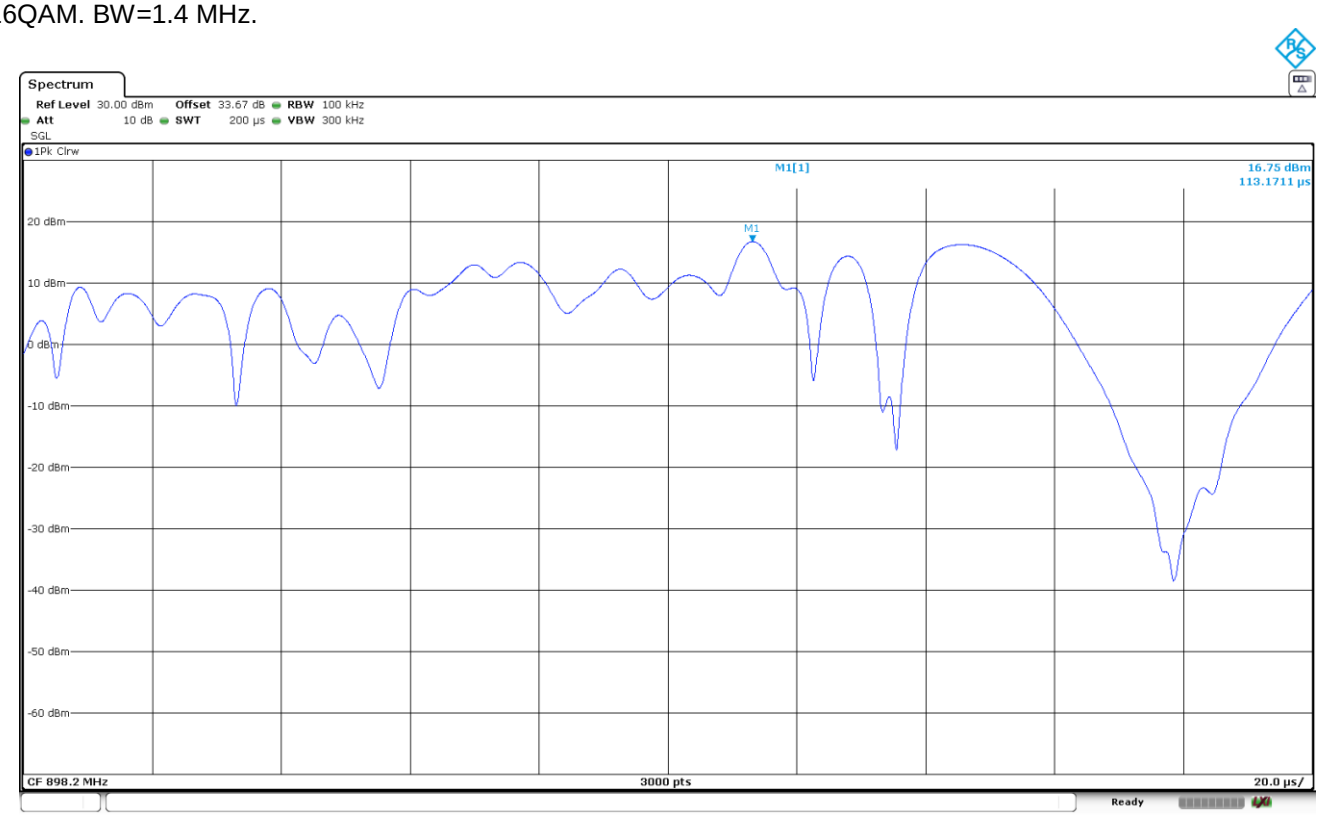
The following plots show the modulation schemes in the EUT.

LTE Cat-M1 Band 8:

QPSK. BW=1.4 MHz.

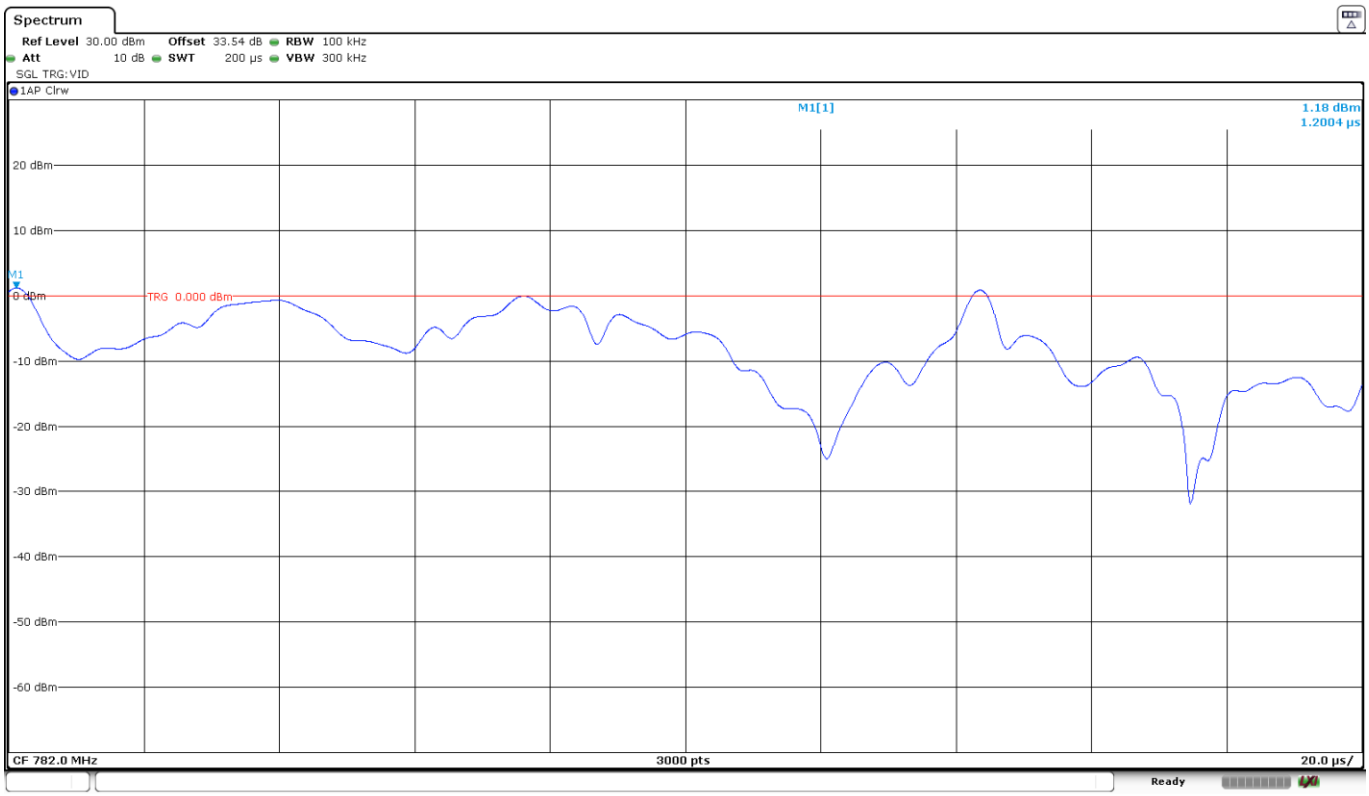


16QAM. BW=1.4 MHz.



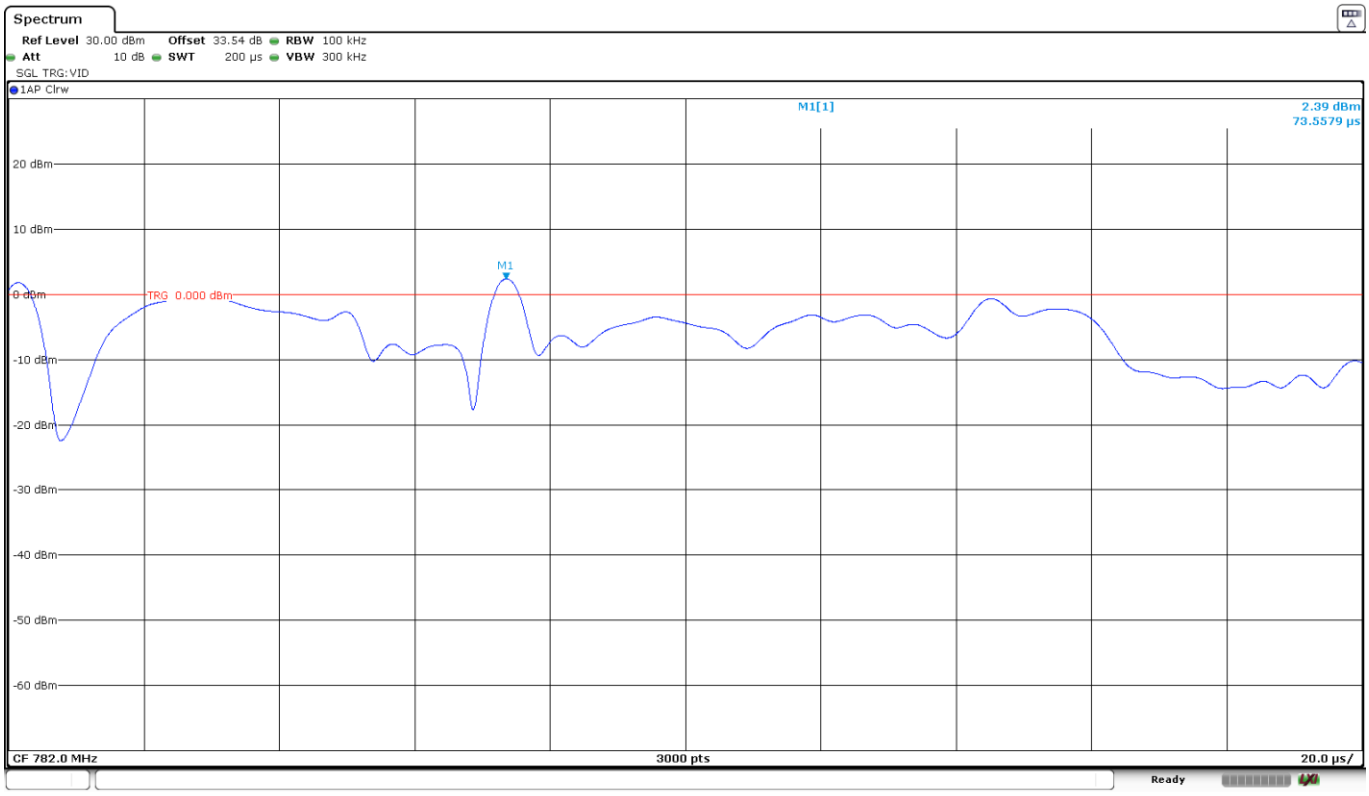
LTE Cat-M1 Band 13:

QPSK. BW=5 MHz.



Date: 8.MAR.2024 20:19:09

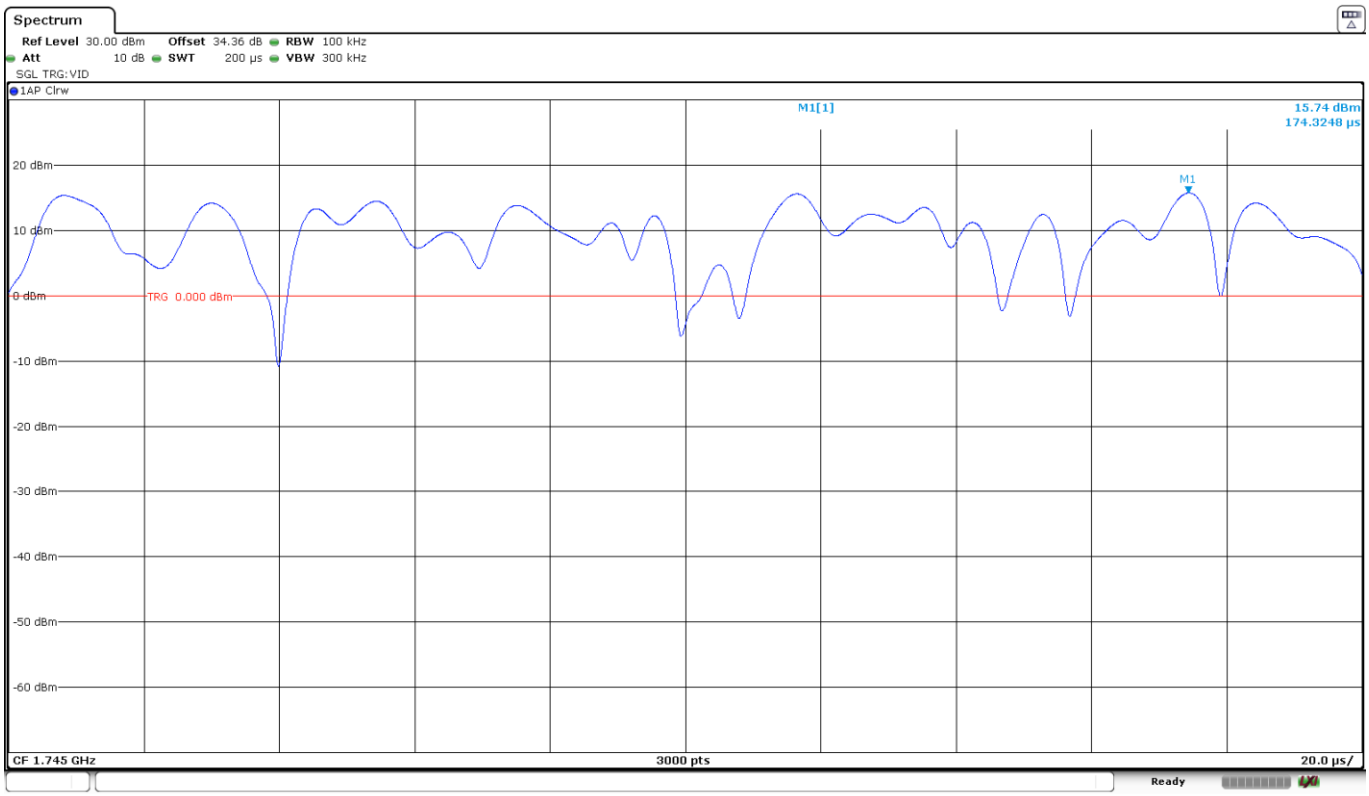
16QAM. BW=5 MHz.



Date: 8.MAR.2024 20:20:22

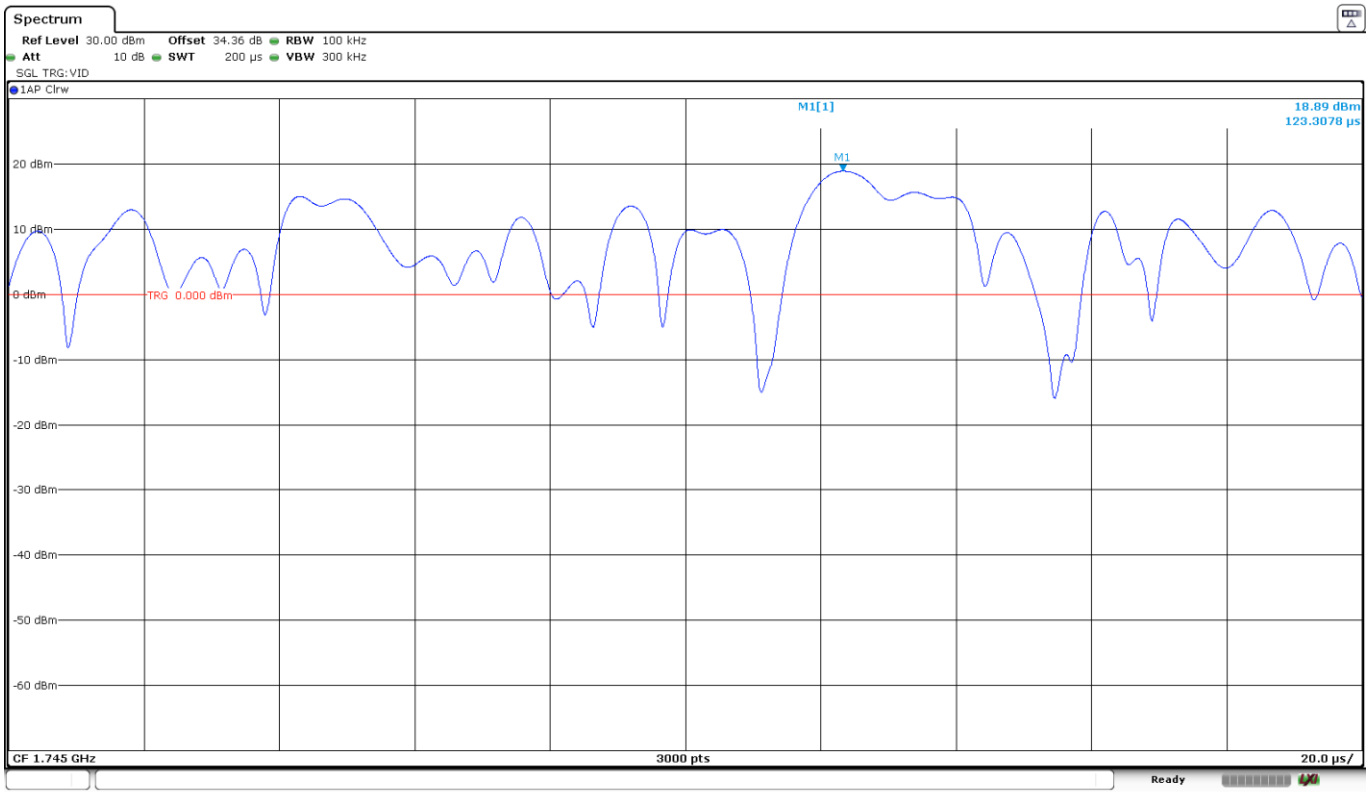
LTE Cat-M1 Band 66:

QPSK. BW=1.4 MHz.



Date: 8.MAR.2024 20:24:49

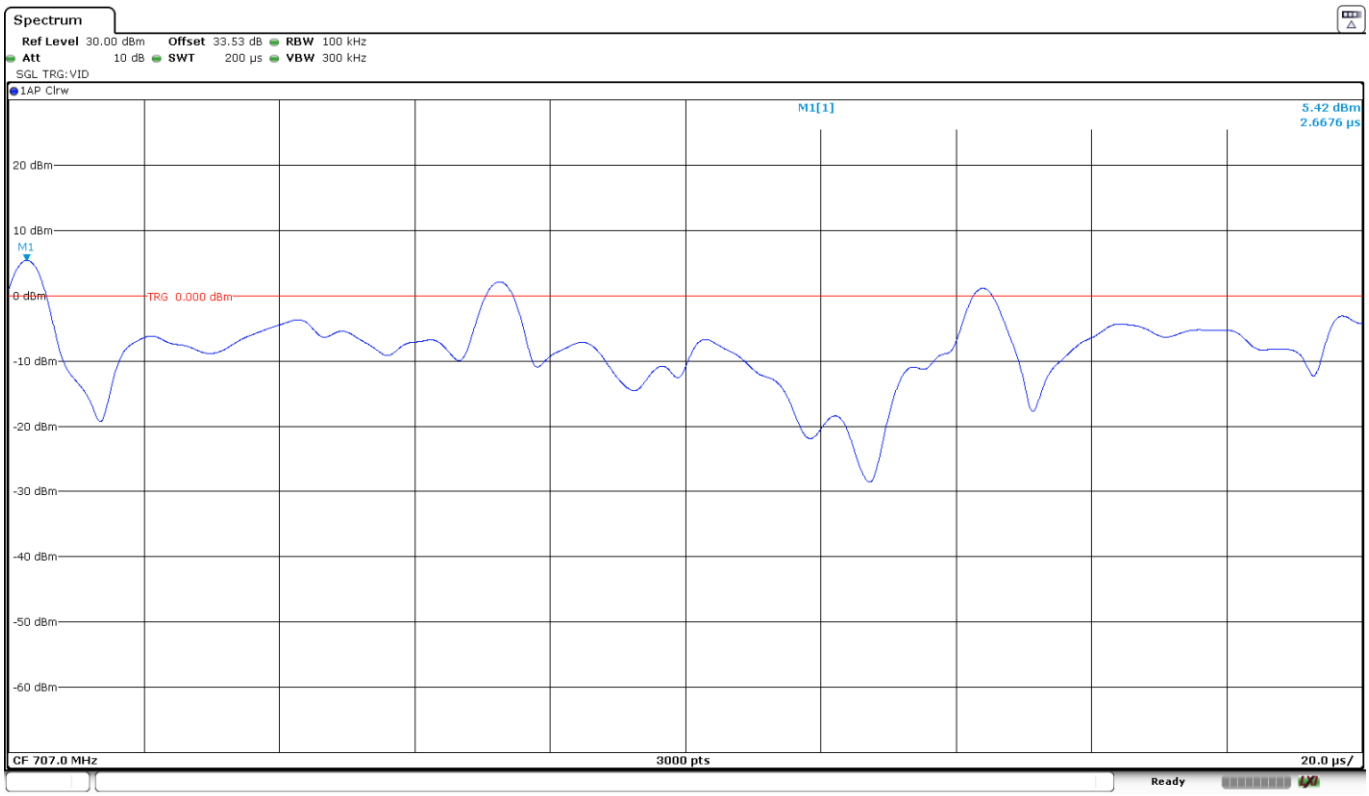
16QAM. BW=1.4 MHz.



Date: 8.MAR.2024 20:23:36

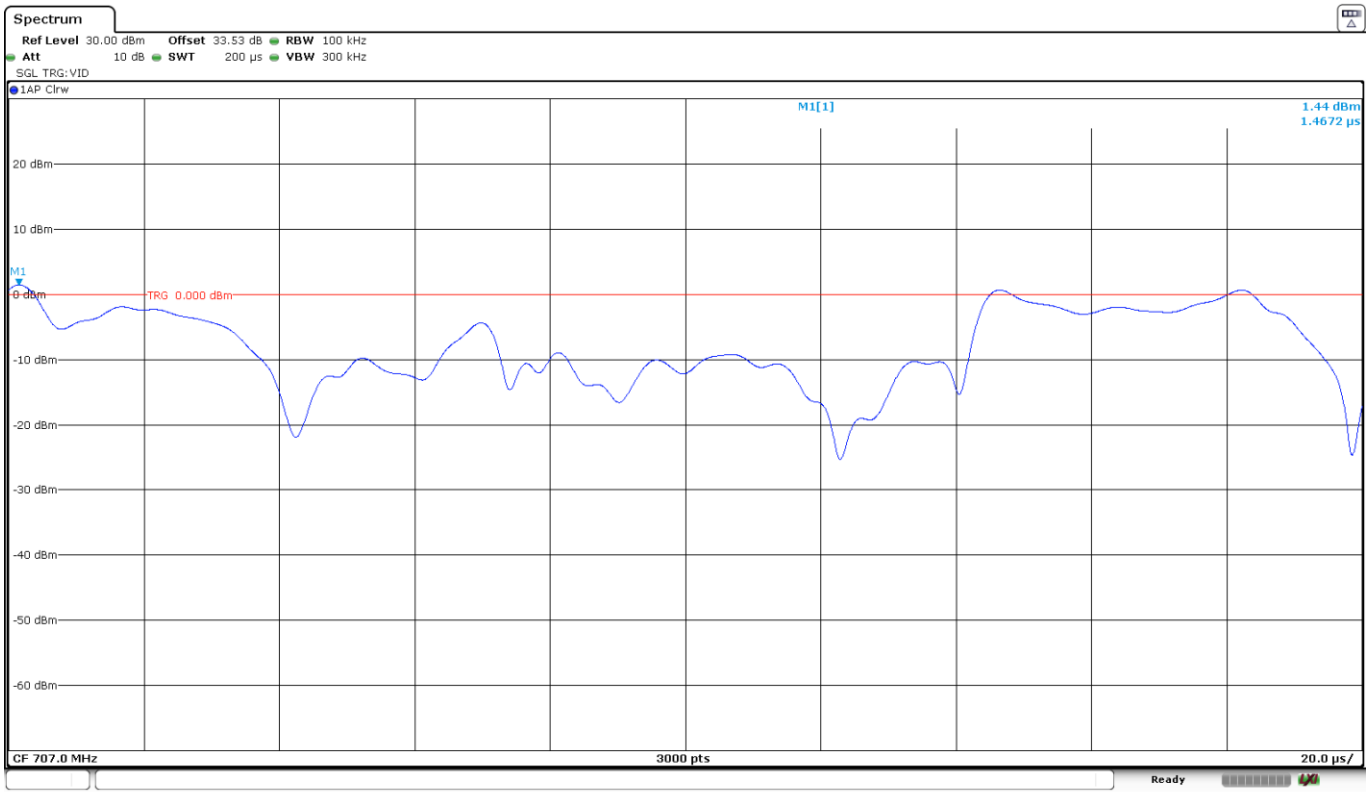
LTE Cat-M1 Band 85:

QPSK. BW=5 MHz.



Date: 8.MAR.2024 20:29:40

16QAM. BW=5 MHz.



Date: 8.MAR.2024 20:27:33

Occupied Bandwidth

Limits

FCC §2.1049: Measurements required: Occupied bandwidth.

RSS-Gen 6.7. The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

The following conditions shall be observed for measuring the occupied bandwidth and x dB bandwidth:

- The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
- The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.
- The detector of the spectrum analyzer shall be set to "Sample". However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or "Max Hold") may be necessary to determine the occupied / x dB bandwidth if the device is not transmitting continuously.
- The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

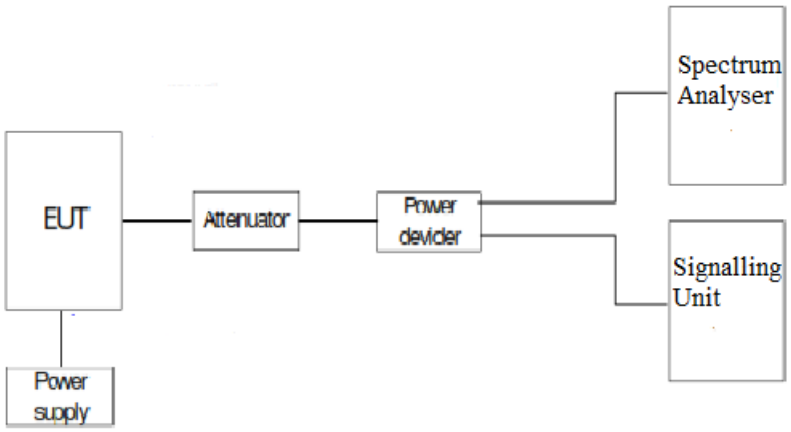
Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

Method

The occupied bandwidth measurement was performed at the output terminals of the EUT using an attenuator. power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation. The 99% occupied bandwidth 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 Narrowband or the Bandwidth selected.

LTE Cat-M1 Band 8:

LTE Cat-M1 Band 8. BW=1.4 MHz. QPSK. RB Size 6.

Channel	Low	High
99% Occupied Bandwidth (MHz)	1.017	1.105
-26 dBc Bandwidth (MHz)	1.326	1.327
Measurement uncertainty (kHz)	<±3.75	

LTE Cat-M1 Band 8. BW=1.4 MHz. 16QAM. RB Size 5.

Channel	Low	High
99% Occupied Bandwidth (MHz)	0.960	0.970
-26 dBc Bandwidth (MHz)	1.315	1.313
Measurement uncertainty (kHz)	<±3.75	

LTE Cat-M1 Band 13:

LTE Cat-M1 Band 13. BW=5 MHz. QPSK. RB Size 6.

Channel	Low	High
99% Occupied Bandwidth (MHz)	1.09433	1.10367
-26 dBc Bandwidth (MHz)	1.34294	1.34168
Measurement uncertainty (kHz)	<±3.75	

LTE Cat-M1 Band 13. BW=5 MHz. 16QAM. RB Size 5.

Channel	Low	High
99% Occupied Bandwidth (MHz)	0.94033	0.94267
-26 dBc Bandwidth (MHz)	1.28930	1.28568
Measurement uncertainty (kHz)	<±3.75	

LTE Cat-M1 Band 66:

LTE Cat-M1 Band 66. BW=1.4 MHz. QPSK. RB Size 6.

Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	1.098	1.097	1.097
-26 dBc Bandwidth (MHz)	1.321	1.325	1.327
Measurement uncertainty (kHz)	<±3.75		

LTE Cat-M1 Band 66. BW=1.4 MHz. 16QAM. RB Size 5.

Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	0.947	0.944	0.939
-26 dBc Bandwidth (MHz)	1.333	1.287	1.291
Measurement uncertainty (kHz)	<±3.75		

LTE Cat-M1 Band 85:

LTE Cat-M1 Band 85. BW=5 MHz. QPSK. RB Size 6.

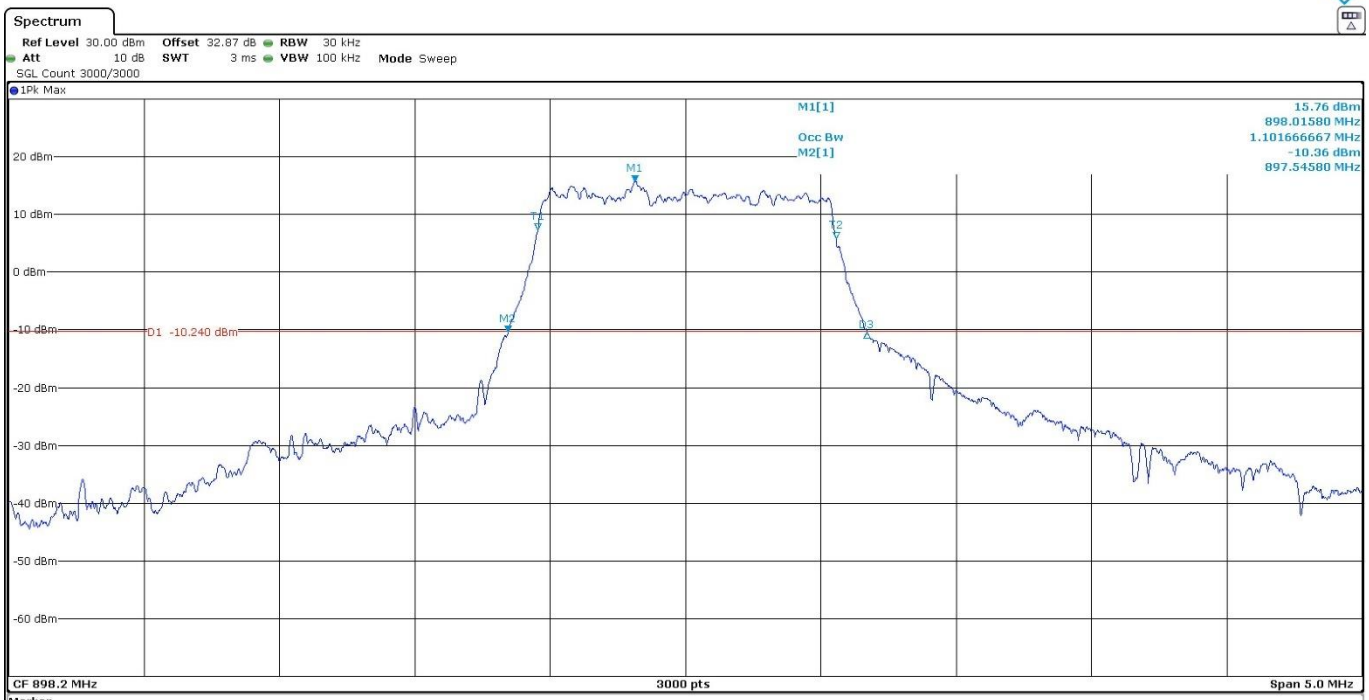
Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	1.104	1.106	1.094
-26 dBc Bandwidth (MHz)	1.335	1.336	1.321
Measurement uncertainty (kHz)	<±3.75		

LTE Cat-M1 Band 85. BW=5 MHz. 16QAM. RB Size 5.

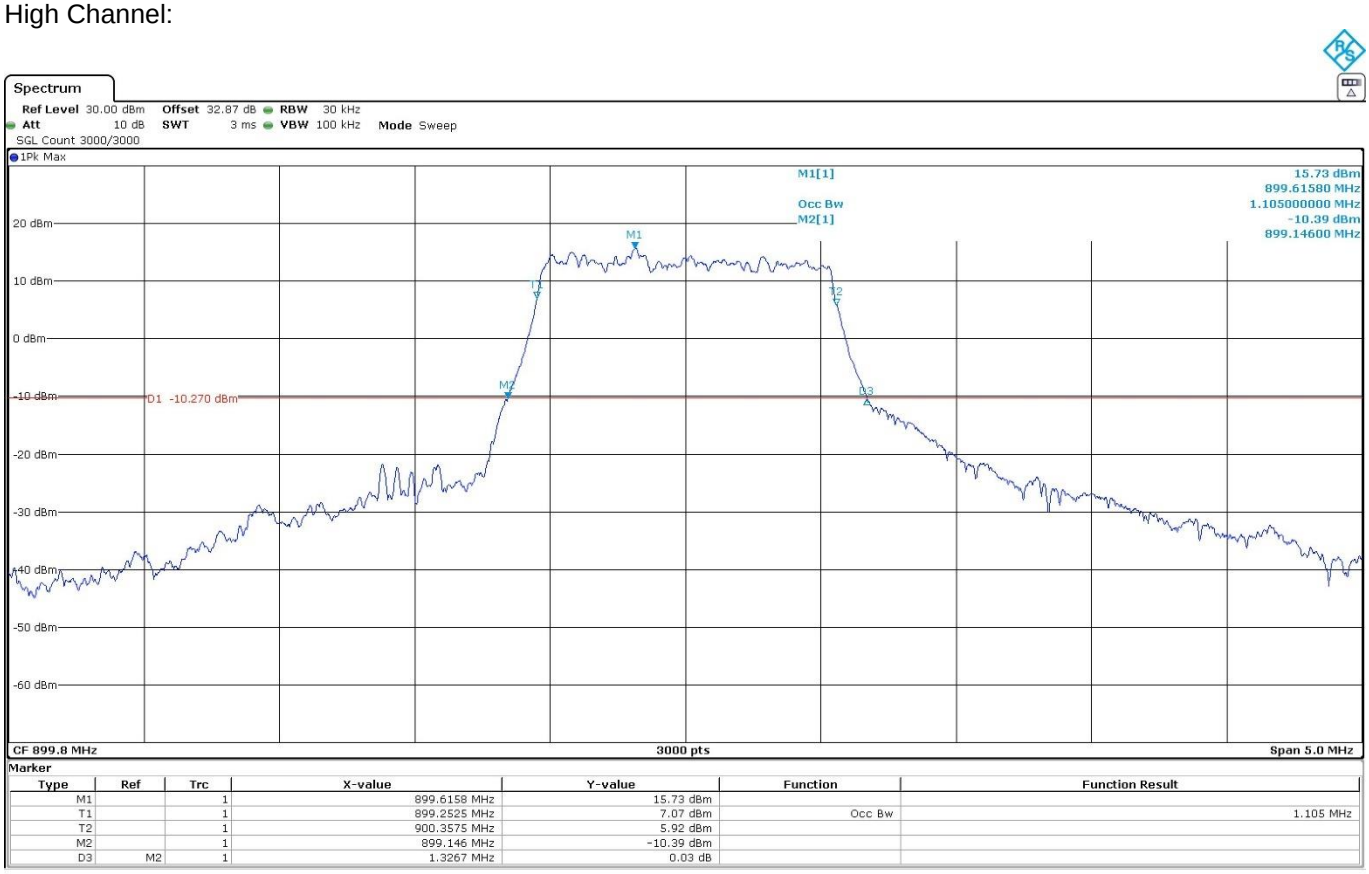
Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	0.973	0.952	0.945
-26 dBc Bandwidth (MHz)	1.316	1.310	1.295
Measurement uncertainty (kHz)	<±3.75		

LTE Cat-M1 Band 8. BW=1.4 MHz. QPSK. RB Size 6.

Low Channel:

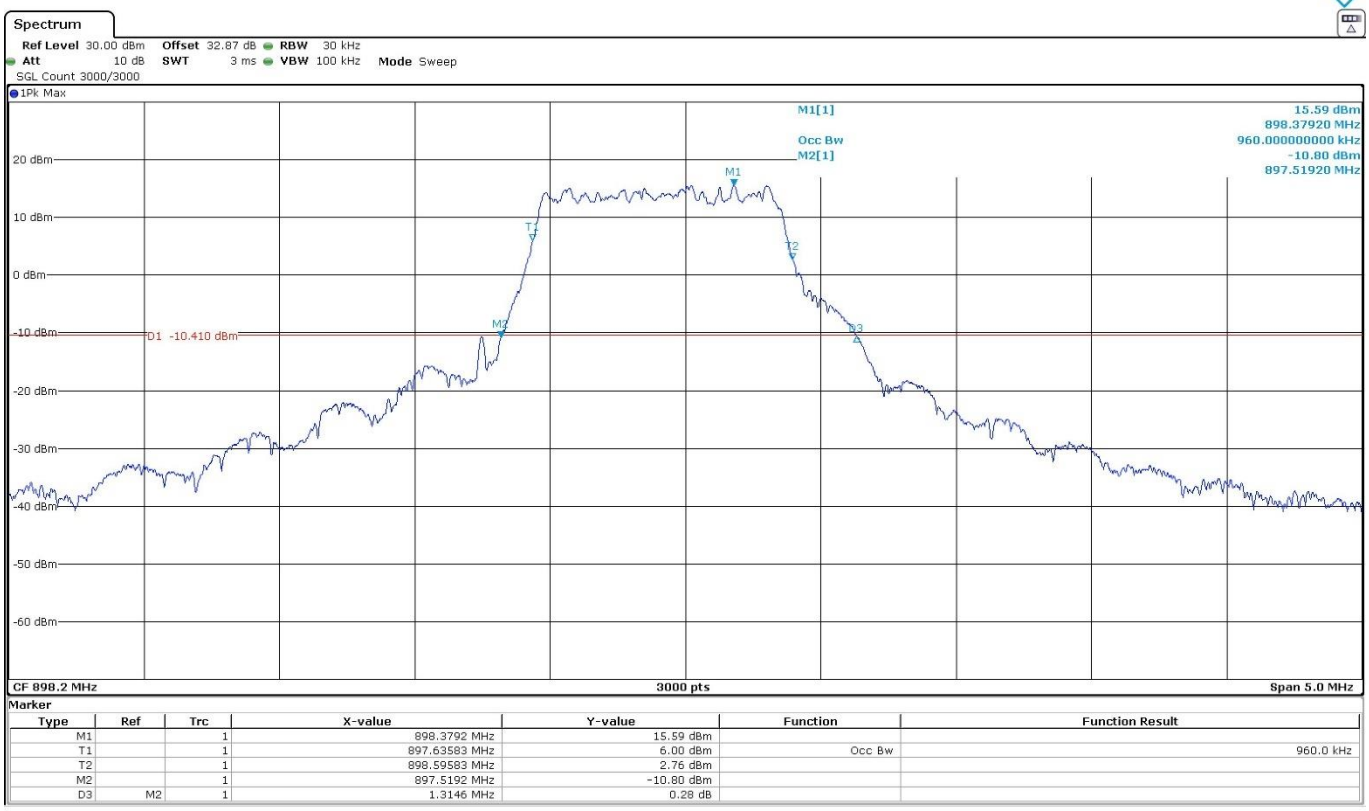


High Channel:

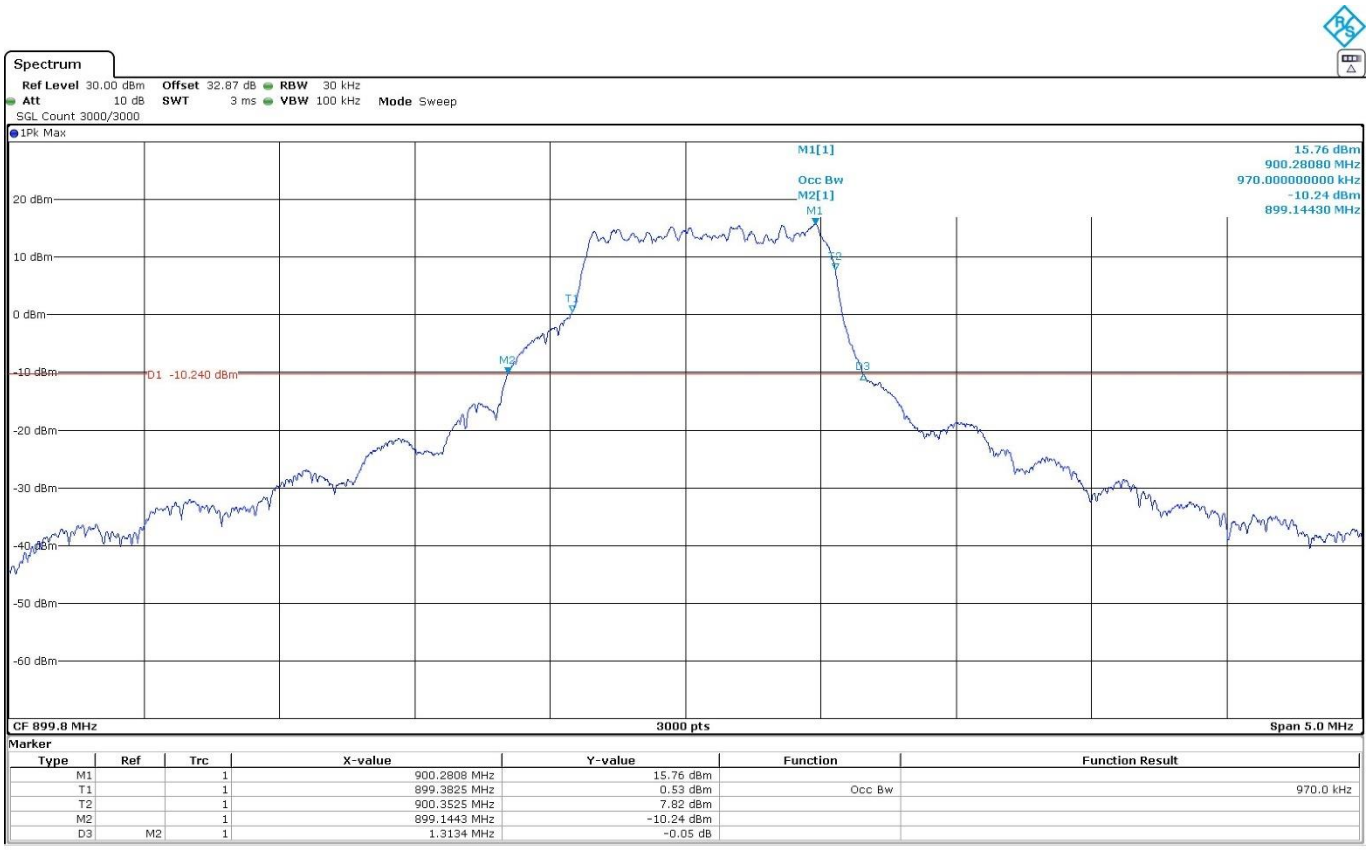


LTE Cat-M1 Band 8. BW=1.4 MHz. 16QAM. RB Size 5.

Low Channel:

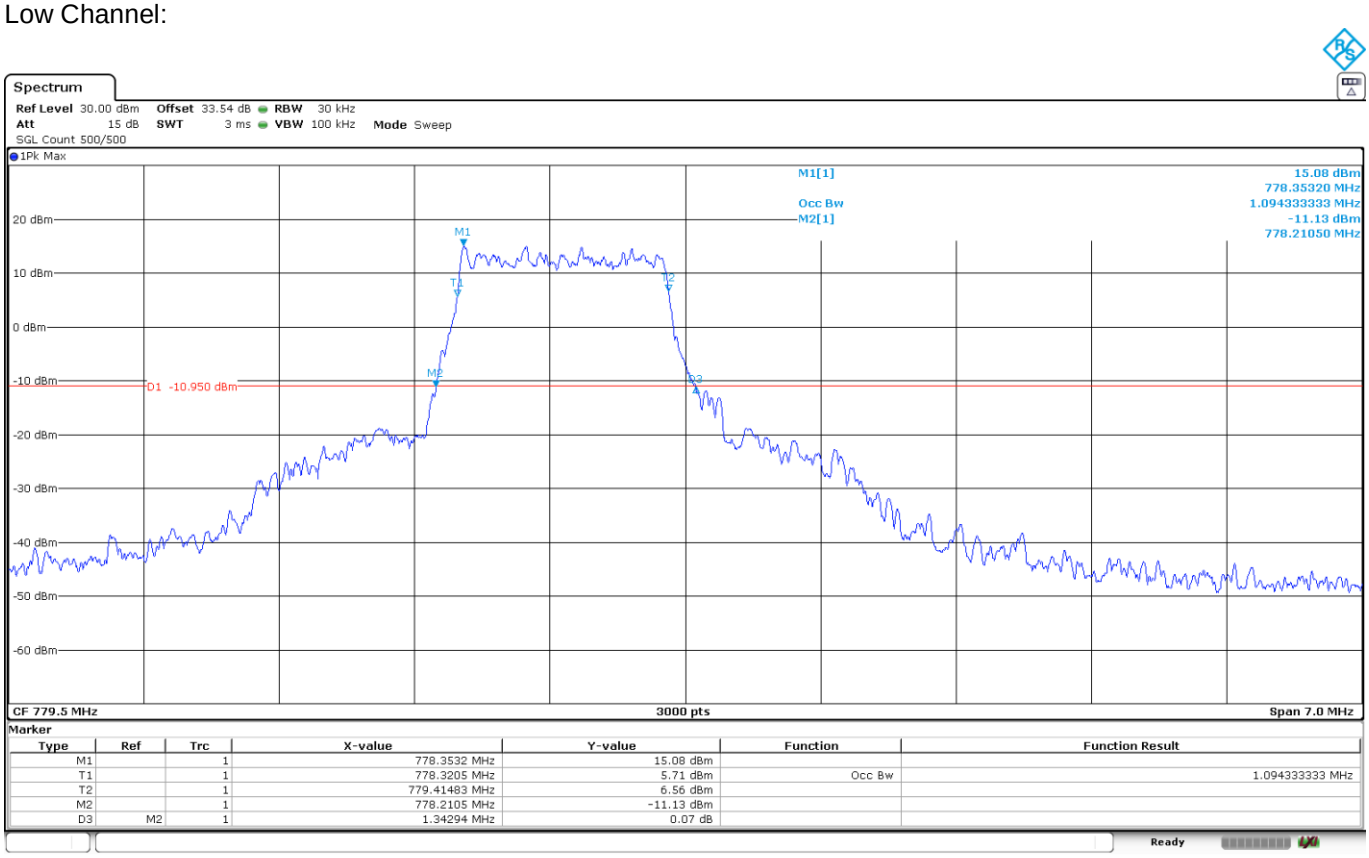


High Channel:

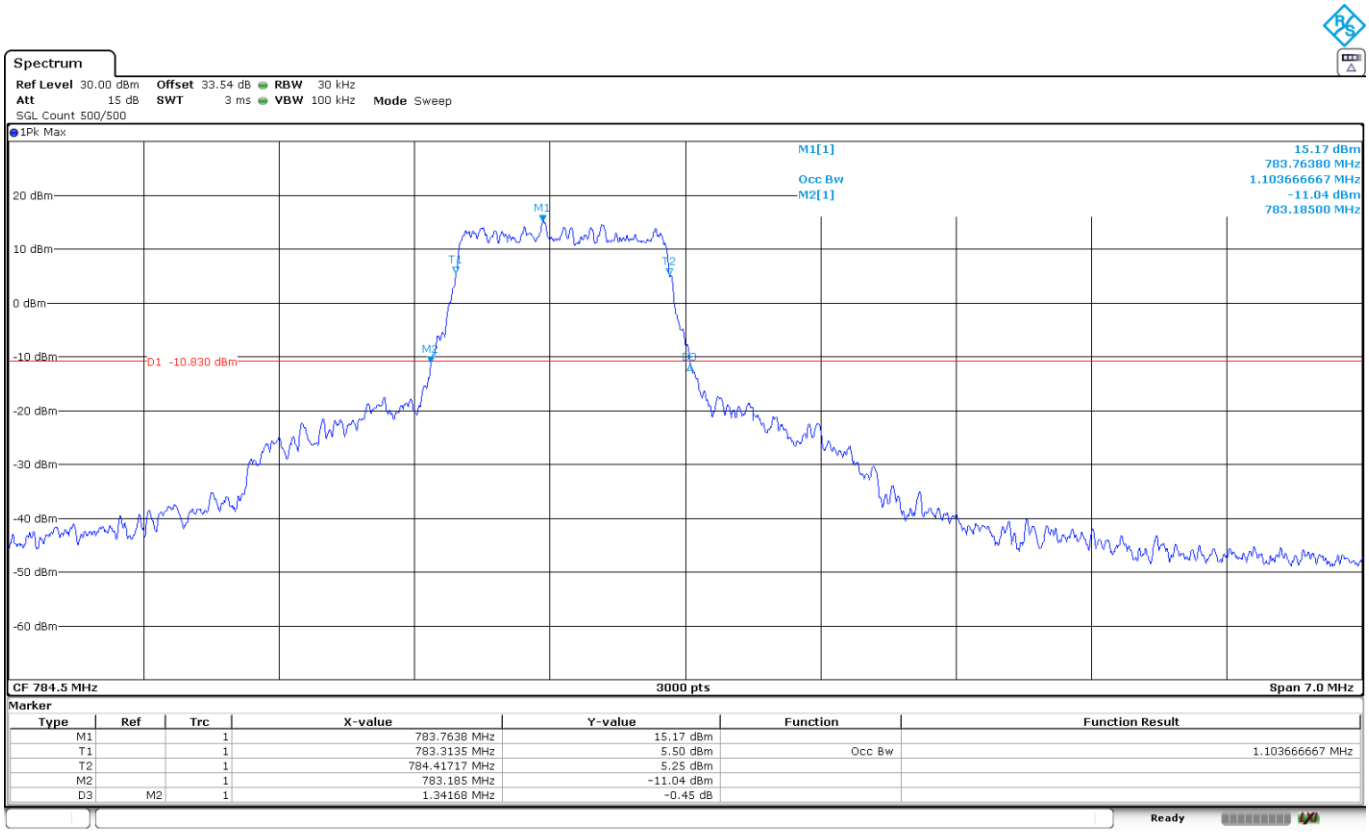


LTE Cat-M1 Band 13. BW=5 MHz. QPSK. RB Size 6.

Low Channel:

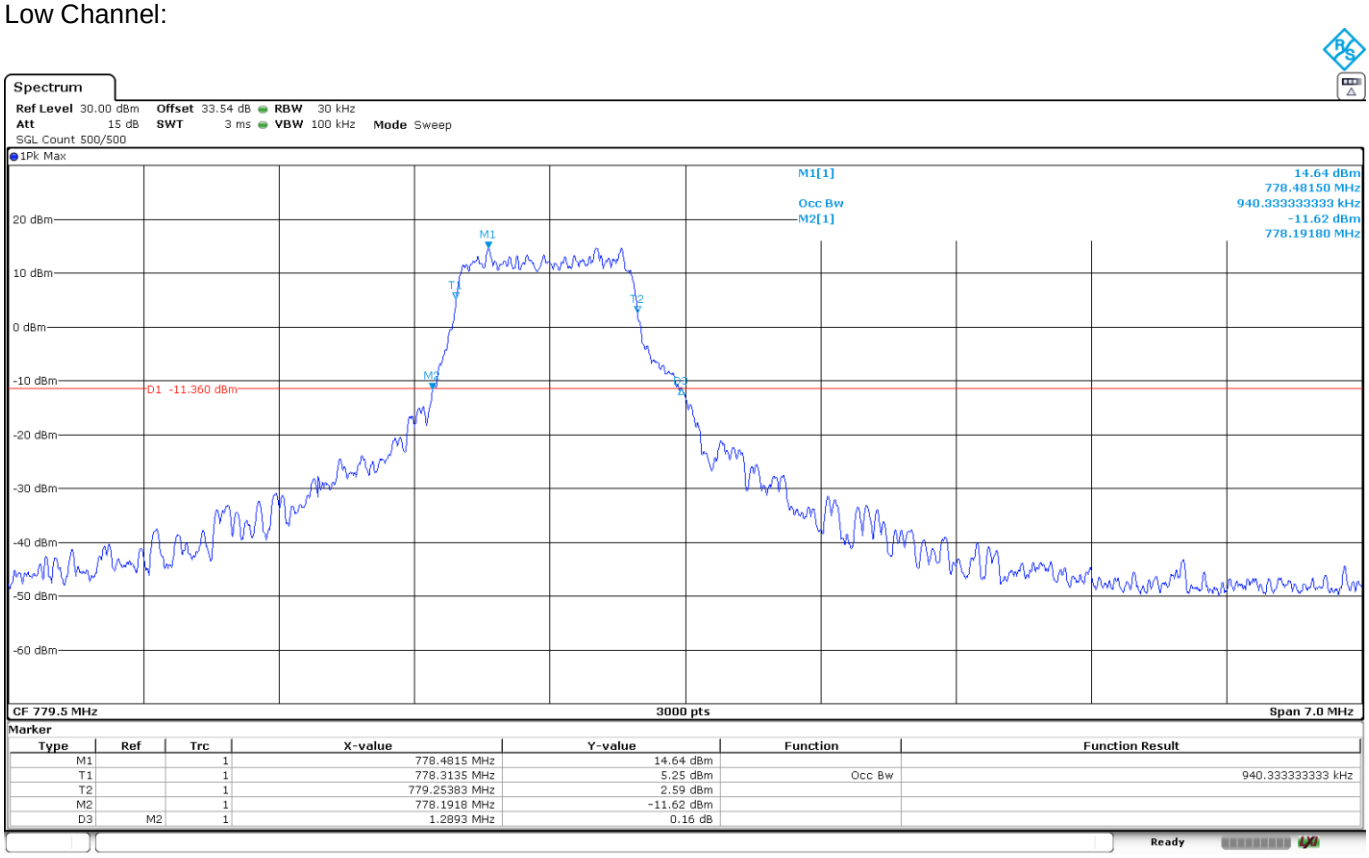


High Channel:



LTE Cat-M1 Band 13. BW=5 MHz. 16QAM. RB Size 5.

Low Channel:



High Channel: