DEKRA Testing and Certification, S.A.U.
Parque Tecnológico de Andalucía,
c/ Severo Ochoa nº 2 · 29590 Campanillas · Málaga · España
C.I.F. A29 507 456

Test report No:
NIE: 67117RRF.003

Test report
Reference Standard:
USA FCC Part 27
CANADA IC RSS-130, RSS-139

(*) Identification of item tested	LTE Cat-M Cellular communication module
(*) Trademark	Sequans Communications
(*) Model and /or type reference	GM02S
Other identification of the product	HW version: GM02Sv2 SW version: LR8.0.0.3-51813 FCC ID: 2AAGMGM02SA IC: 12732A-GM02SA IMEI TAC: 01577000
(*) Features	LTE-M, 3GPP LTE Release 14
Applicant	Sequans Communications 55 Boulevard Charles de Gaulle, 92700 Colombes, France
Test method requested, standard	USA FCC Part 27 (10-1-19 Edition). CANADA RSS-130 Issue 2, Feb. 2019. CANADA RSS-139 Issue 3, Jul. 2015. ANSI C63.26: 2015. KDB 971168 D01 Power Meas License Digital Systems v03r01, April 2018.
Summary	IN COMPLIANCE
Approved by (name / position & signature)	Rafael López Martín EMC Consumer & RF Lab. Manager 2021.03.12 14:06:52 +01'00'
Date of issue	2021-03-11
Report template No	FDT08_23 (*) "Data provided by the client"

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Competences and guarantees

DEKRA Testing and Certification S.A.U. is a testing laboratory competent to carry out the tests described in this report.

DEKRA Testing and Certification is a FCC-recognized accredited testing laboratory with appropriate scope of accreditation that include testing performed in this test report.

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

DEKRA Testing and Certification S.A.U. guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and it is based on the knowledge and technical facilities available at DEKRA Testing and Certification S.A.U. at the time of performance of the test.

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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 of the model GM02S is a multi-band module supporting cellular LTE-M release 14. It supports HD-FDD.

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
67117/010	LTE Cat-M Cellular communication module	GM02S	G2K2101030003050	2021/02/03
67117/009	External Antenna	OmniLOG 90200	--	2021/02/03

Auxiliary elements used with the Sample S/01:

Control Nº	Description	Model	Serial Nº	Date of reception
67117/010	NEKTAR-B Evaluation Kit	HWPT011B4	--	2021/02/03
67117/012	UFL to SMA Cable	--	--	2021/02/03

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

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

Control Nº	Description	Model	Serial Nº	Date of reception
67117/010	LTE Cat-M Cellular communication module	GM02S	G2K2101030003050	2021/02/03

Auxiliary elements used with the Sample S/02:

Control Nº	Description	Model	Serial Nº	Date of reception
67117/010	NEKTAR-B Evaluation Kit	HWPT011B4	--	2021/02/03
67117/011	USB Cable	--	--	2021/02/03
67117/012	UFL to SMA Cable	--	--	2021/02/03

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

Test sample description

Ports……:	Port name and description		Cable					
			Specified max length [m]	Attached during test	Shielded	Coupled to patient(3)		
	USB		2	☒	☐	☐		
				☐	☐	☐		
Supplementary information to the ports…… :	N/A							
Rated power supply .....:	Voltage and Frequency		Reference poles					
			L1	L2	L3	N	PE	
	☐	AC:	☐	☐	☐	☐	☐	
	☒	DC: 3.3Vdc						
Rated Power .....:	Not provided data							
Clock frequencies.....:	Not provided data							
Other parameters .....:	Not provided data							
Software version .....:	LR8.0.0.3-51813							
Hardware version .....:	GM02Sv2							
Dimensions in cm (W x H x D) ....:	Not provided data							
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		
	NEKTAR-B-GM02S			Eval Kit		Sequans		
	USB Cable							
	External antenna					Aaronia AG		
Accessories (not part of the test item) .....:	Description			Type		Manufacturer		
	N/A							
Documents as provided by the applicant.....:	Description			File name		Issue date		
	User Manual			NEKTAR-B_EvalKitUserManual-Rev2		2020-11-20		
	AT Commands Reference Manual			GM02S -LR80-ATCommandsRefMan_Rev2		2020-11-13		

(3) Only for Medical Equipment

Identification of the client

SEQUANS COMMUNICATIONS

55 Boulevard Charles de Gaulle, 92700 Colombes, France

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2021-02-11
Date (finish)	2021-03-08

Document history

Report number	Date	Description
67117RRF.003	2021-03-11	First release

Environmental conditions

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

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

In the semianechoic chamber, the following limits were not exceeded during the test.

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

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

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 35 %

Remarks and comments

The tests have been performed by the technical personnel: Cristina Calle, Miguel Manuel López and Nicolás Salguero.

Used instrumentation:

Conducted Measurements

		Last Cal. date	Cal. due date
1.	Shielded Room ETS LINDGREN S101	N.A.	N.A.
2.	Spectrum analyser Rohde & Schwarz FSV40	2019/09	2021/09
3.	Signal analyzer Rohde & Schwarz FSQ8	2020/10	2022/10
4.	Climatic chamber HERAEUS VMT 04/35	2020/07	2022/07
5.	DC Power Supply Keysight Technologies U8002A	--	--
6.	Digital multimeter FLUKE 179	2020/10	2021/10
7.	Universal Radio communication Tester R&S CMW50	2020/04	2021/04

Radiated Measurements

		Last Cal. date	Cal. due date
1.	Semianechoic Absorber Lined Chamber ETS FACT3 200STP	N.A.	N.A.
2.	Shielded Room ETS LINDGREN S101	N.A.	N.A.
3.	BiconicalLog antenna ETS LINDGREN 3142E	2020/10	2023/10
4.	Broadband Horn antenna 1-18 GHz SCHWARZBECK BBHA 9120 D	2020/08	2023/08
5.	EMI Test Receiver Rohde & Schwarz ESR7	2019/10	2021/10
6.	Spectrum analyser Rohde & Schwarz FSV40	2019/10	2021/10
7.	RF pre-amplifier 1-18 GHz Bonn Elektronik BLMA 0118-3A	2020/10	2021/10
8.	Wideband Radio Communication Tester ROHDE AND SCHWARZ CMW500	2020/04	2021/04

Testing verdicts

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

Summary

FCC PART 27 / RSS-130, RSS-139 PARAGRAPH Requirement – Test case	Verdict	Remark
FCC 27.50 / RSS-130 4.6, RSS-139 6.5: RF Output Power	P	
FCC 2.1047 / RSS-130 4.2, RSS-139 6.2: Modulation Characteristics	P	
FCC 27.54 / RSS-130 4.5, RSS-139 6.4: Frequency Stability	P	
FCC 2.1049 / RSS-130 4.5, RSS-139 6.4: Occupied Bandwidth	P	
FCC 27.53 / RSS-130 4.7, RSS-139 6.6: Spurious Emissions at Antenna Terminals	P	
FCC 27.53 / RSS-130 4.7, RSS-139 6.6: Radiated Emissions	P	
Supplementary information and remarks: None.		

Appendix A: Test results for FCC Part 27 / RSS-130, RSS-139

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TEST CONDITIONS

Power supply (V):

Vn = 3.3 Vdc

Vmin = 2.805 Vdc

Vmax = 3.795 Vdc

The subscripts nom, min and max indicate voltage test conditions (nominal, minimum and maximum respectively), as declared by the applicant.

Type of power supply: DC Voltage from external power supply.

ANTENNA:

Device with external and internal antennas.

After a preliminary scan, the determined worst case for the Radiated tests is the external antenna.

For the Conducted tests, the gain of the internal antenna is used.

Declared Gain for antennas:

Low bands	Gain (dBi)	Antenna type
LTE Bands 12, 13 and 17	+1.1	Internal
	+0.17	External

Middle bands	Gain (dBi)	Antenna type
LTE Bands 4 and 66	+2.4	Internal
	+2.1	External

TEST FREQUENCIES:

LTE Band 4. QPSK AND 16QAM MODULATIONS.

	Channel per Nominal Bandwidth (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)

(*) The EUT does not support the Nominal Bandwidths 1.4 MHz, 3 MHz.

NOTE: Band 4 is completely included in band 66, so the channels of band 66 were tested to give conformity to the assigned block 1710-1780 MHz. Only high block edge of band 4 was tested to give conformity to the assigned block 1710-1755 MHz.

LTE Band 12: QPSK AND 16QAM MODULATIONS.

	Channel per Nominal Bandwidth (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)

(*) The EUT does not support the Nominal Bandwidths 1.4 MHz, 3 MHz.

LTE Band 13: QPSK AND 16QAM MODULATIONS.

	Channel per Nominal Bandwidth (Frequency, MHz)	
	BW = 5 MHz	BW = 10 MHz
Low	23205 (779.5)	N/A
Middle	23230 (782)	23230 (782)
High	23255 (784.5)	N/A

LTE Band 17. QPSK AND 16QAM MODULATIONS.

	Channel per Nominal Bandwidth (Frequency, MHz)	
	BW = 5 MHz	BW = 10 MHz
Low	23755 (706.5)	23780 (709)
Middle	23790 (710)	23790 (710)
High	23825 (713.5)	23800 (711)

NOTE: Band 17 is completely included in band 12, so the channels of band 12 were tested to give conformity to the assigned block.

LTE Band 66. QPSK AND 16QAM MODULATIONS.

	Channel per Nominal Bandwidth (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)

(*) The EUT does not support the Nominal Bandwidths 1.4 MHz, 3 MHz.

RF Output Power

SPECIFICATION

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.

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.

FCC §27.50 (d) (4) & (5):

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.

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-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.

RSS-139 Clause 6.5:

The equivalent isotropically radiated power (e.i.r.p.) for mobile and portable transmitters shall not exceed one watt. The e.i.r.p. for fixed and base stations in the band 1710-1780 MHz shall not exceed one watt.

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

E.R.P. = E.I.R.P. – 2.15 dB

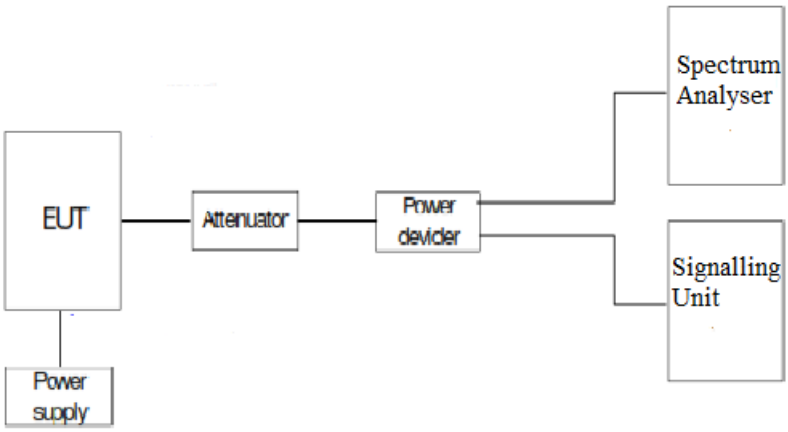
The peak-to-average power ratio (PAPR) is measured using an attenuator, power splitter and spectrum analyser with a Complementary Cumulative Distribution Function implemented.

The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

TEST SETUP

1. Conducted average power:

2. Peak-to-average power ratio (PAPR):



RESULTS

1. CONDUCTED AVERAGE POWER:

LTE BAND 12:

Preliminary measurements determined the narrow band = 0 and Nominal Bandwidth of 5 MHz as the worst case. The next results are for the worst-case configuration.

BANDWIDTH (MHz)	CHANNEL	FREQUENCY (MHz)	MODULATION	RB SIZE	RB OFFSET	AVERAGE POWER (dBm)	PAPR (dB)
5	23035	701.5	QPSK	1	0	22.99	
				6	0	22.14	4.42
			16QAM	1	0	22.80	
				5	0	21.19	5.18
	23095	707.5	QPSK	1	0	22.92	
				6	0	22.06	4.28
			16QAM	1	0	22.83	
				5	0	21.10	4.94
	23155	713.5	QPSK	1	0	23.06	
				6	0	22.28	4.74
			16QAM	1	0	22.99	
				5	0	21.32	5.30

LTE BAND 13:

Preliminary measurements determined the narrow band = 0 and Nominal Bandwidth of 5 MHz as the worst case. The next results are for the worst-case configuration.

BANDWIDTH (MHz)	CHANNEL	FREQUENCY (MHz)	MODULATION	RB SIZE	RB OFFSET	AVERAGE POWER (dBm)	PAPR (dB)
5	23205	779.5	QPSK	1	0	23.08	
				6	0	22.16	4.44
			16QAM	1	0	22.88	
				5	0	21.17	5.10
	23230	782	QPSK	1	0	22.93	
				6	0	22.09	4.46
			16QAM	1	0	22.80	
				5	0	21.10	5.14
	23255	784.5	QPSK	1	0	23.06	
				6	0	22.23	4.47
			16QAM	1	0	23.01	
				5	0	21.23	4.89

LTE BAND 66:

Preliminary measurements determined the narrow band = 0 and Nominal Bandwidth of 20 MHz as the worst case. The next results are for the worst-case configuration.

BANDWIDTH (MHz)	CHANNEL	FREQUENCY (MHz)	MODULATION	RB SIZE	RB OFFSET	AVERAGE POWER (dBm)	PAPR (dB)
20	132072	1720	QPSK	1	0	23.05	
				6	0	23.04	4.02
			16QAM	1	0	22.93	
				5	0	22.91	4.42
	132322	1745	QPSK	1	0	23.04	
				6	0	23.03	4.17
			16QAM	1	0	22.89	
				5	0	22.87	4.36
	132572	1770	QPSK	1	0	22.99	
				6	0	22.97	3.99
			16QAM	1	0	22.93	
				5	0	22.79	4.31

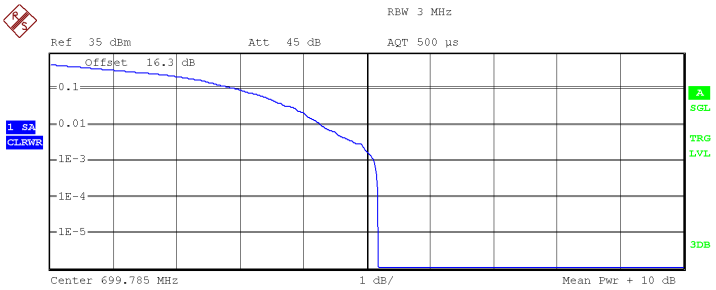
2. PEAK-TO-AVERAGE POWER RATIO (PAPR):

LTE Band 12:

Preliminary measurements determined the narrow band = 0, Nominal Bandwidth of 5 MHz, 16QAM modulation and 5 RB size, offset 0 as the worst case.

The next results are for this worst-case configuration.

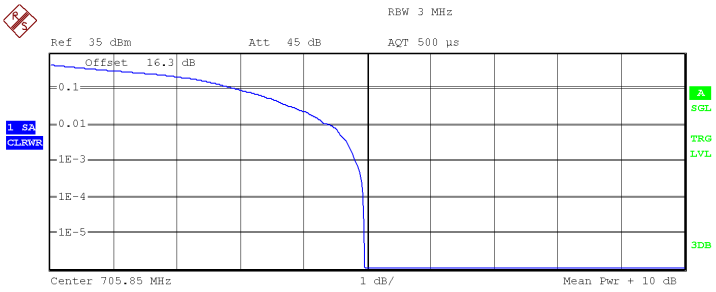
Low Channel:



Complementary Cumulative Distribution Function
NOF samples: 2000, Usable BW: 3.5MHz

	Trace 1
Mean	21.17 dBm
Peak	26.35 dBm
Crest	5.18 dB
10 %	2.95 dB
1 %	4.28 dB
.1 %	5.11 dB
.01 %	5.18 dB

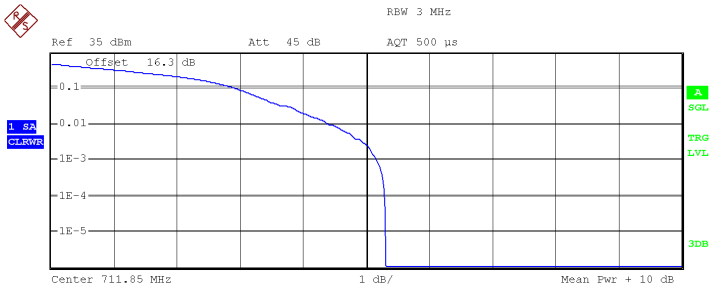
Middle Channel:



Complementary Cumulative Distribution Function
NOF samples: 2000, Usable BW: 3.5MHz

	Trace 1
Mean	21.19 dBm
Peak	26.14 dBm
Crest	4.95 dB
10 %	2.95 dB
1 %	4.41 dB
.1 %	4.82 dB
.01 %	4.94 dB

High Channel:



Complementary Cumulative Distribution Function
NOF samples: 2000, Usable BW: 3.5MHz

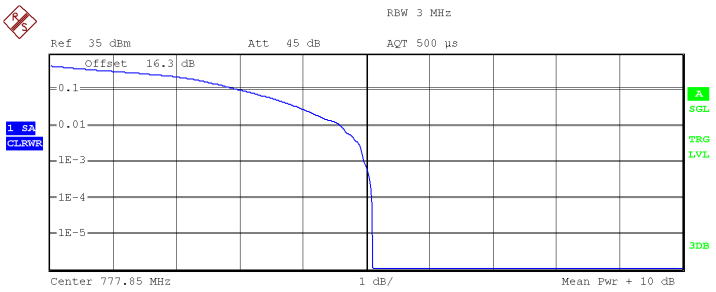
	Trace 1
Mean	21.18 dBm
Peak	26.49 dBm
Crest	5.30 dB
10 %	2.93 dB
1 %	4.39 dB
.1 %	5.18 dB
.01 %	5.30 dB

LTE Band 13:

Preliminary measurements determined the narrow band = 0, Nominal Bandwidth of 5 MHz, 16QAM modulation and 5 RB size, offset 0 as the worst case.

The next results are for this worst-case configuration.

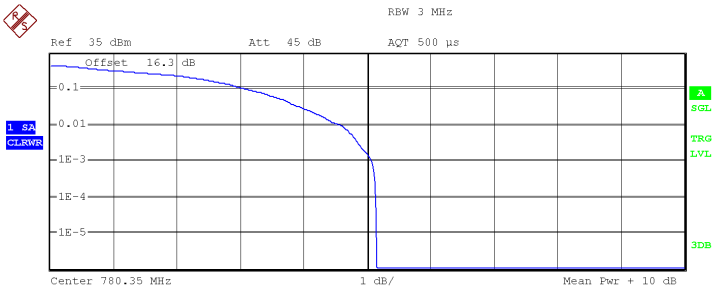
Low Channel:



Complementary Cumulative Distribution Function
NOF samples: 2000, Usable BW: 3.5MHz

	Trace 1
Mean	21.26 dBm
Peak	26.36 dBm
Crest	5.10 dB
10 %	3.00 dB
1 %	4.60 dB
.1 %	4.97 dB
.01 %	5.10 dB

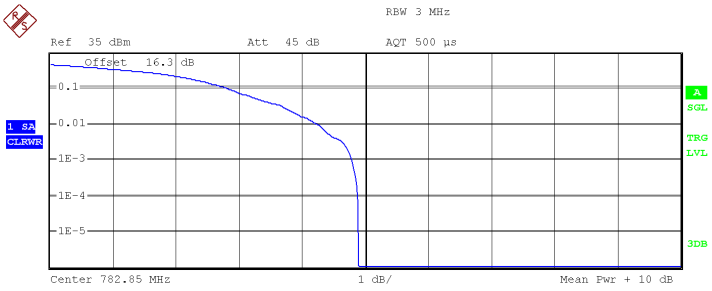
Middle Channel:



Complementary Cumulative Distribution Function
NOF samples: 2000, Usable BW: 3.5MHz

	Trace 1
Mean	21.15 dBm
Peak	26.29 dBm
Crest	5.14 dB
10 %	3.08 dB
1 %	4.58 dB
.1 %	5.08 dB
.01 %	5.14 dB

High Channel:



Complementary Cumulative Distribution Function
NOF samples: 2000, Usable BW: 3.5MHz

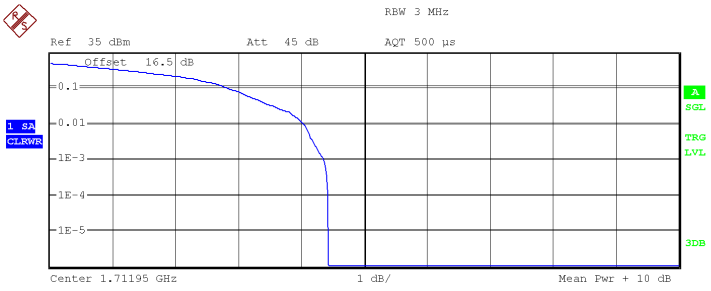
	Trace 1
Mean	21.40 dBm
Peak	26.29 dBm
Crest	4.89 dB
10 %	2.80 dB
1 %	4.25 dB
.1 %	4.79 dB
.01 %	4.89 dB

LTE Band 66:

Preliminary measurements determined the narrow band = 0, Nominal Bandwidth of 20 MHz, 16QAM modulation and 5 RB size, offset 0 as the worst case.

The next results are for this worst-case configuration.

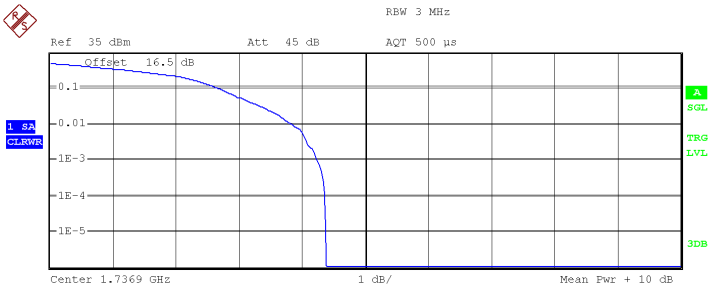
Low Channel:



Complementary Cumulative Distribution Function
NOF samples: 2000, Usable BW: 3.5MHz

	Trace 1
Mean	22.17 dBm
Peak	26.59 dBm
Crest	4.43 dB
10 %	2.84 dB
1 %	4.04 dB
.1 %	4.36 dB
.01 %	4.42 dB

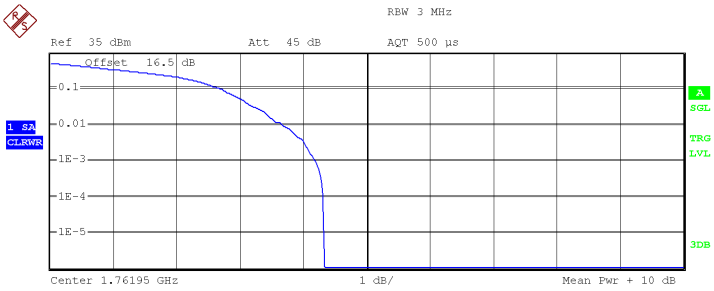
Middle Channel:



Complementary Cumulative Distribution Function
NOF samples: 2000, Usable BW: 3.5MHz

	Trace 1
Mean	22.43 dBm
Peak	26.80 dBm
Crest	4.37 dB
10 %	2.68 dB
1 %	3.83 dB
.1 %	4.25 dB
.01 %	4.36 dB

High Channel:



Complementary Cumulative Distribution Function
NOF samples: 2000, Usable BW: 3.5MHz

	Trace 1
Mean	22.55 dBm
Peak	26.87 dBm
Crest	4.32 dB
10 %	2.69 dB
1 %	3.67 dB
.1 %	4.18 dB
.01 %	4.31 dB

LTE Band 12:

Channel	Measured maximum average power (dBm) at antenna port	Maximum declared antenna gain (dBi)	Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm)	Maximum effective radiated power E.R.P. (dBm)	PAPR (dB)
Low	22.99	1.1	24.09	21.94	5.18
Middle	22.92	1.1	24.02	21.87	4.94
High	23.06	1.1	24.16	22.01	5.30
Measurement uncertainty (dB)	<±0.94				

LTE Band 13:

Channel	Measured maximum average power (dBm) at antenna port	Maximum declared antenna gain (dBi)	Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm)	Maximum effective radiated power E.R.P. (dBm)	PAPR (dB)
Low	23.08	1.1	24.18	22.03	5.10
Middle	22.93	1.1	24.03	21.88	5.14
High	23.06	1.1	24.16	22.01	4.89
Measurement uncertainty (dB)	<±0.94				

LTE Band 66:

Channel	Measured maximum average power (dBm) at antenna port	Maximum declared antenna gain (dBi)	Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm)	Maximum effective radiated power E.R.P. (dBm)	PAPR (dB)
Low	23.05	2.4	25.45	23.30	4.42
Middle	23.04	2.4	25.44	23.29	4.36
High	22.99	2.4	25.39	23.24	4.31
Measurement uncertainty (dB)	<±0.94				

Verdict: PASS

Frequency Stability

SPECIFICATION

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, Clause 6.4. The frequency stability shall be sufficient to ensure that the occupied bandwidth remains within each frequency block range when tested at 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.

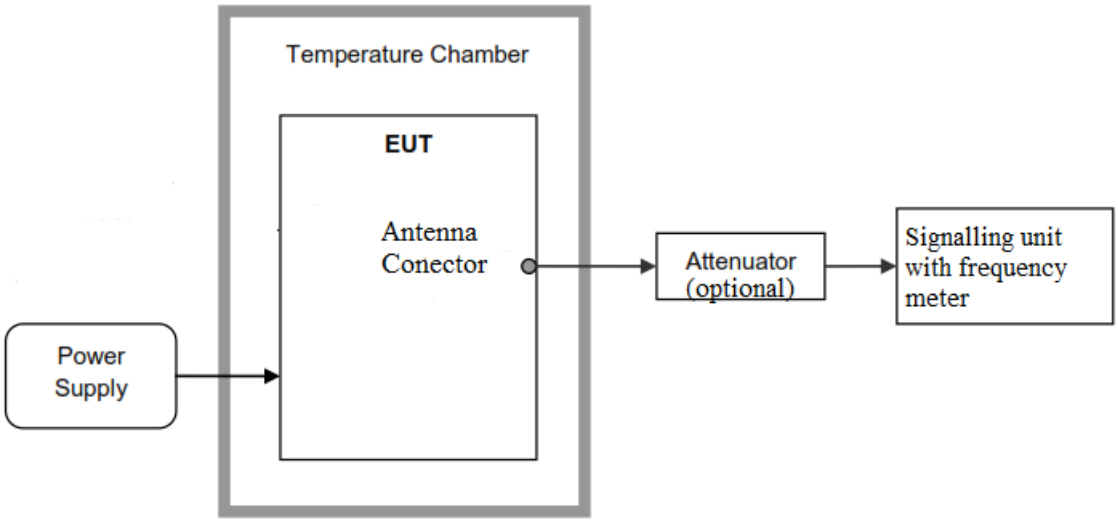
The EUT was set in “Radio Resource Control (RRC) mode” on the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case LTE mode for conducted power was used for the test.

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.

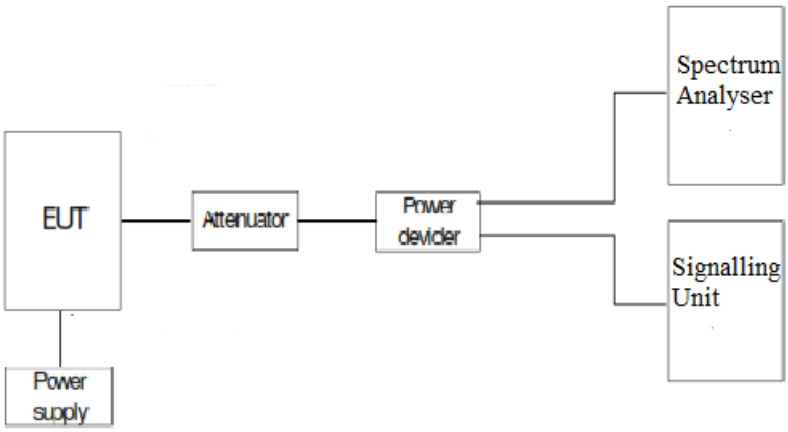
The reference point measurements were made at the RF output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

TEST SETUP

Frequency tolerance:



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



RESULTS

1. FREQUENCY TOLERANCE:

- **Frequency stability over temperature variations.**

LTE Band 12:

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+50	-10.58	-0.014954064
+40	-13.96	-0.019731449
+30	-14.09	-0.019915194
+20	-11.77	-0.016636042
+10	-14.27	-0.020169611
0	-13.67	-0.019321555
-10	-14.99	-0.021187279
-20	-13.62	-0.019250883
-30	-14.39	-0.020339223

LTE Band 13:

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+50	-19.04	-0.024347826
+40	-19.06	-0.024373402
+30	-20.13	-0.025741688
+20	-22.56	-0.028849105
+10	-19.48	-0.024910486
0	-22.36	-0.028593350
-10	-20.04	-0.025626598
-20	-19.95	-0.025511509
-30	-19.90	-0.025447570

LTE Band 66:

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+50	-14.94	-0.008561605
+40	-14.82	-0.008492837
+30	-7.31	-0.004189112
+20	-18.67	-0.010699140
+10	-20.59	-0.011799427
0	-18.94	-0.010853868
-10	-15.30	-0.008767908
-20	-21.20	-0.012148997
-30	-15.23	-0.008727794

- **Frequency stability over voltage variations.**

LTE Band 12:

Battery Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	3.795	-11.42	-0.016141343
Vmin	2.805	-13.01	-0.018388693

LTE Band 13:

Battery Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	3.795	-24.28	-0.031048593
Vmin	2.805	-23.06	-0.029488491

LTE Band 66:

Battery Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	3.795	-20.31	-0.011638968
Vmin	2.805	-19.13	-0.010962751

2. REFERENCE FREQUENCY POINTS fL AND fH:

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

LTE Band 12: QPSK. Nominal bandwidth 5MHz

*f*L (MHz)	698.974100
*f*H (MHz)	715.960600

LTE Band 13: QPSK. Nominal bandwidth 5MHz

*f*L (MHz)	777.026900
*f*H (MHz)	786.981760

LTE Band 66: QPSK. Nominal bandwidth 5MHz

*f*L (MHz)	1710.049190
*f*H (MHz)	1779.913480

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

SPECIFICATION

FCC §2.1047.

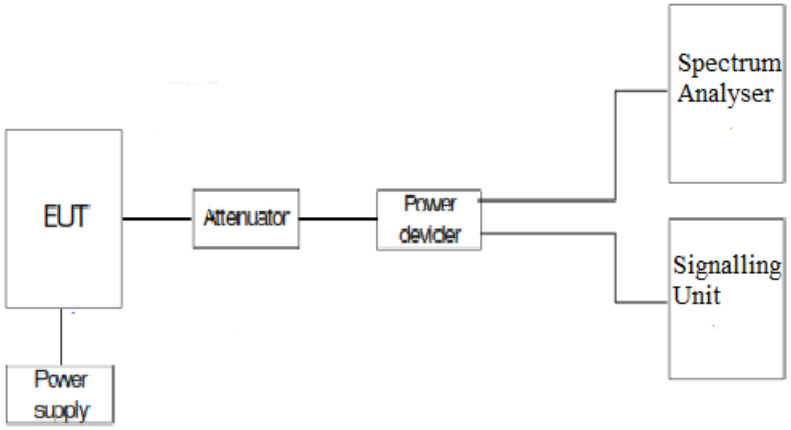
RSS-130, Clause 4.2: Equipment certified under this standard shall employ digital modulation.

RSS-139, Clause 6.2: The devices may employ any type of modulation techniques. The type of modulation used must be reported.

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

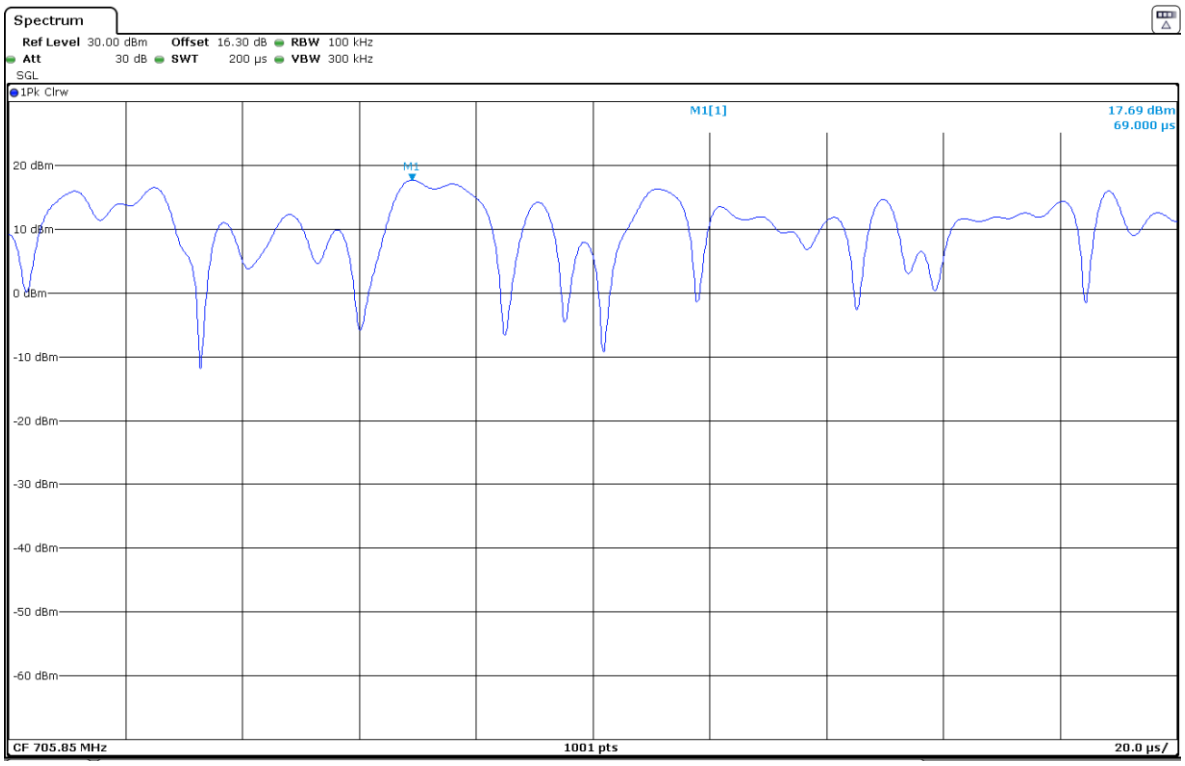


RESULTS

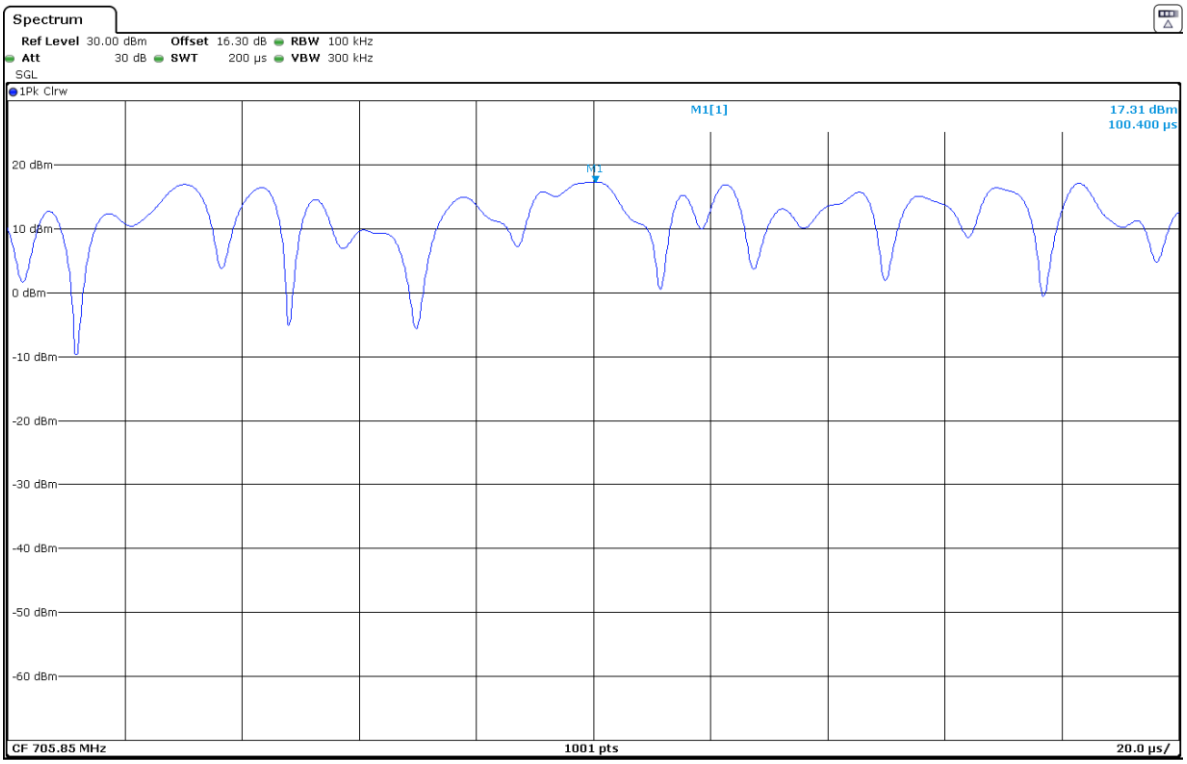
The following plots show the modulation schemes in the EUT.

LTE Band 12:

QPSK. Nominal Bandwidth 5 MHz.

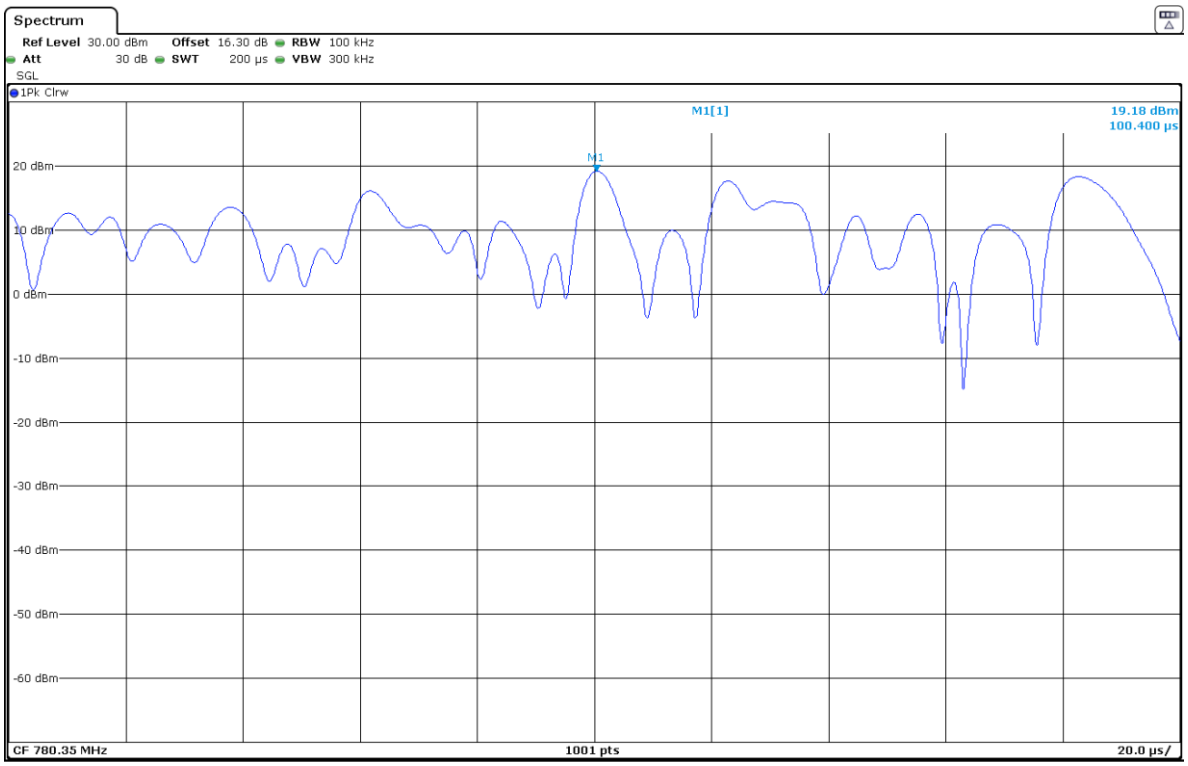


16QAM. Nominal Bandwidth 5 MHz.

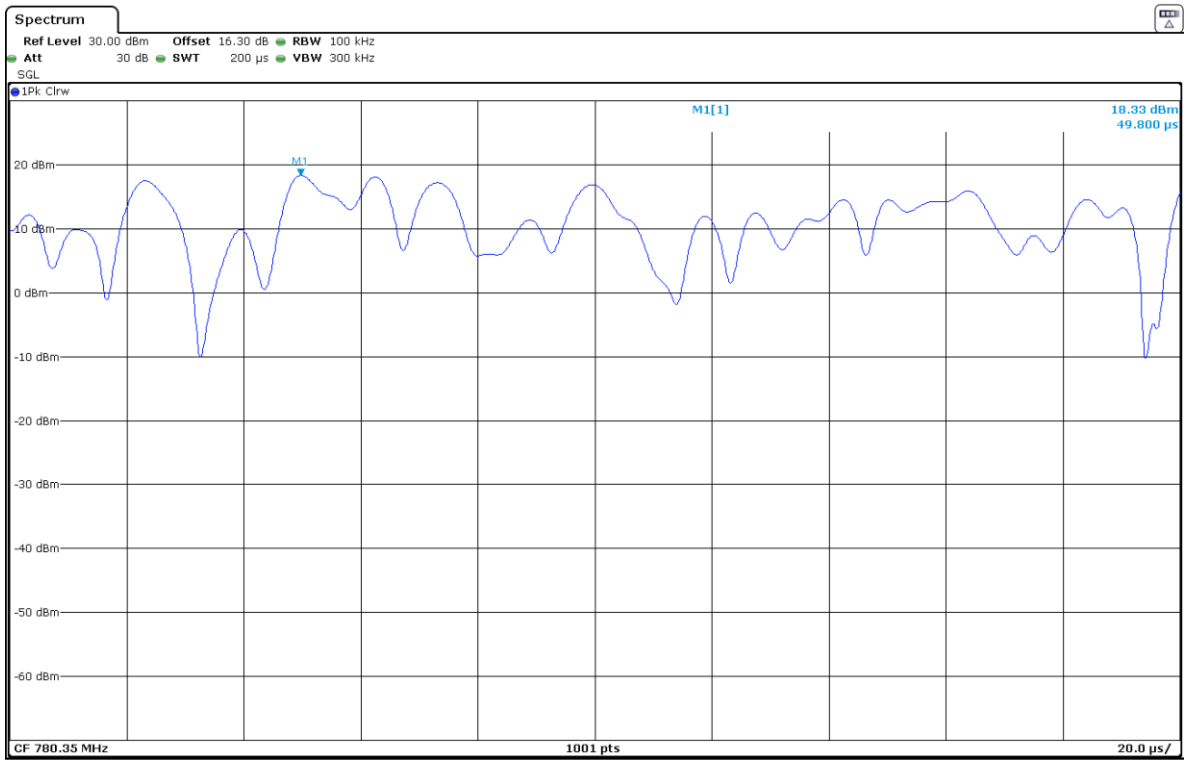


LTE Band 13:

QPSK. Nominal Bandwidth 5 MHz.

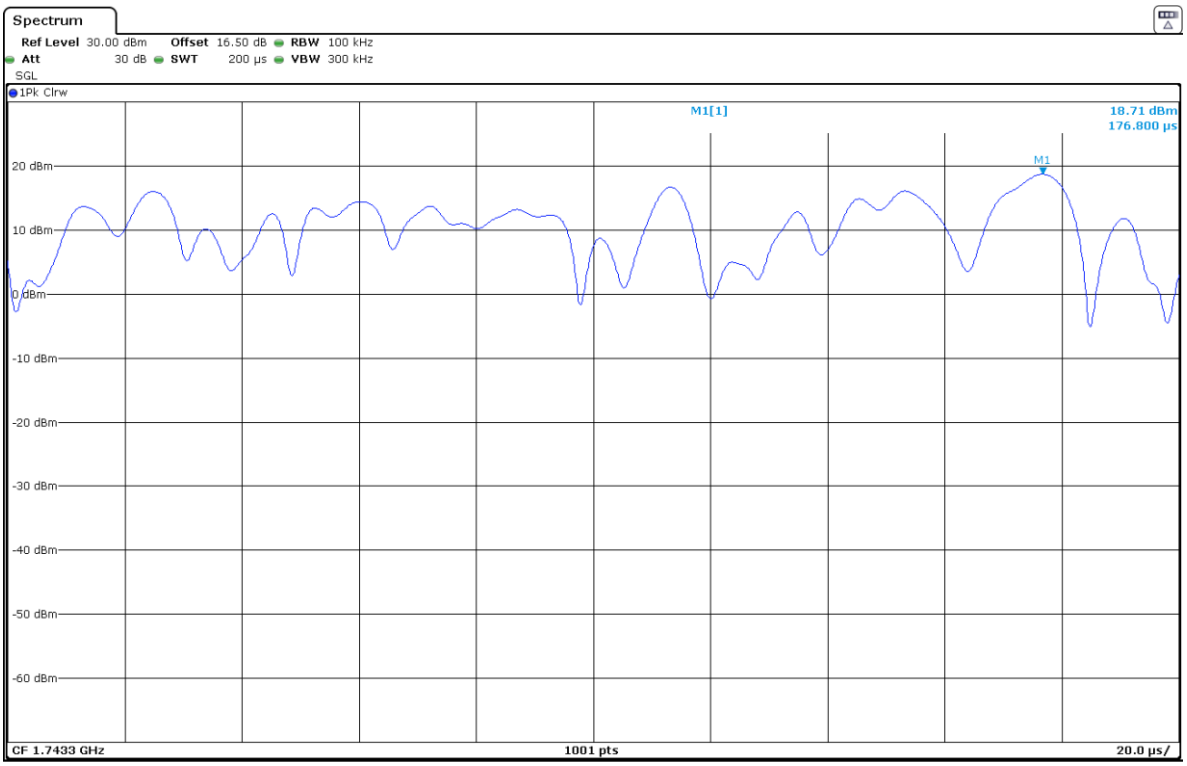


16QAM. Nominal Bandwidth 5 MHz.

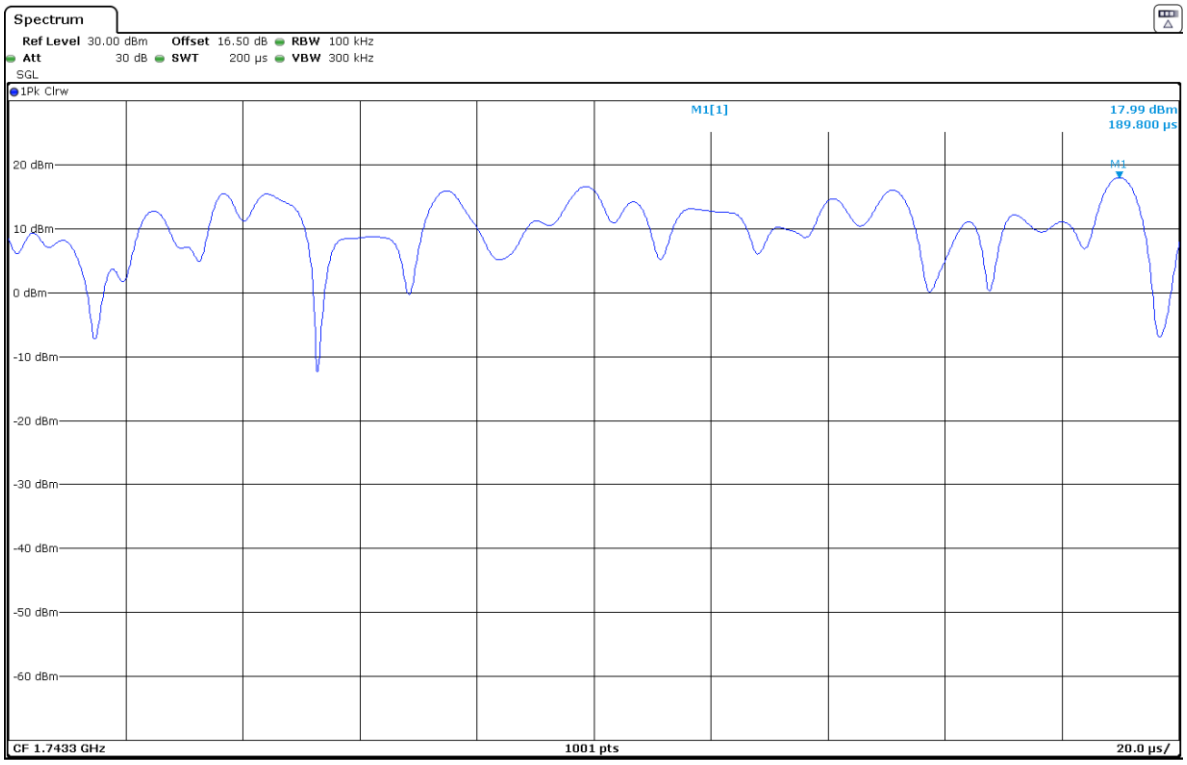


LTE Band 66:

QPSK. Nominal Bandwidth 5 MHz.



16QAM. Nominal Bandwidth 5 MHz.



Occupied Bandwidth

SPECIFICATION

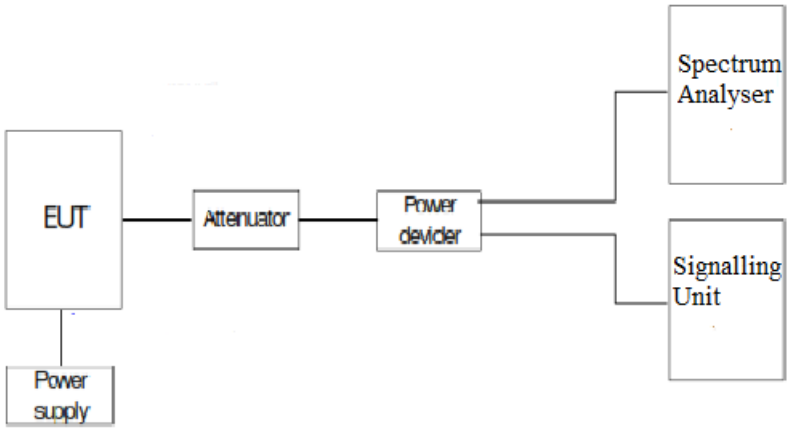
FCC §2.1049: Measurements required: Occupied bandwidth.

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 (see next plots)

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

LTE Band 12:

QPSK. Nominal Bandwidth 5 MHz. Narrow band = 0, Position 1.

Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	1.1105	1.1120	1.1090
-26 dBc Bandwidth (MHz)	1.39812	1.43392	1.41819
Measurement uncertainty (kHz)	<±3.75		

16QAM. Nominal Bandwidth 5 MHz. Narrow band = 0, Position 1.

Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	0.9540	0.9540	0.9575
-26 dBc Bandwidth (MHz)	1.40179	1.36443	1.36607
Measurement uncertainty (kHz)	<±3.75		

LTE Band 13:

QPSK. Nominal Bandwidth 5 MHz. Narrow band = 0, Position 1.

Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	1.1065	1.1110	1.1125
-26 dBc Bandwidth (MHz)	1.42784	1.42010	1.44436
Measurement uncertainty (kHz)	<±3.75		

16QAM. Nominal Bandwidth 5 MHz. Narrow band = 0, Position 1.

Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	0.9485	0.9560	0.9575
-26 dBc Bandwidth (MHz)	1.37710	1.37657	1.39562
Measurement uncertainty (kHz)	<±3.75		

LTE Band 66:

QPSK. Nominal Bandwidth 5 MHz. Narrow band = 0, Position 1.

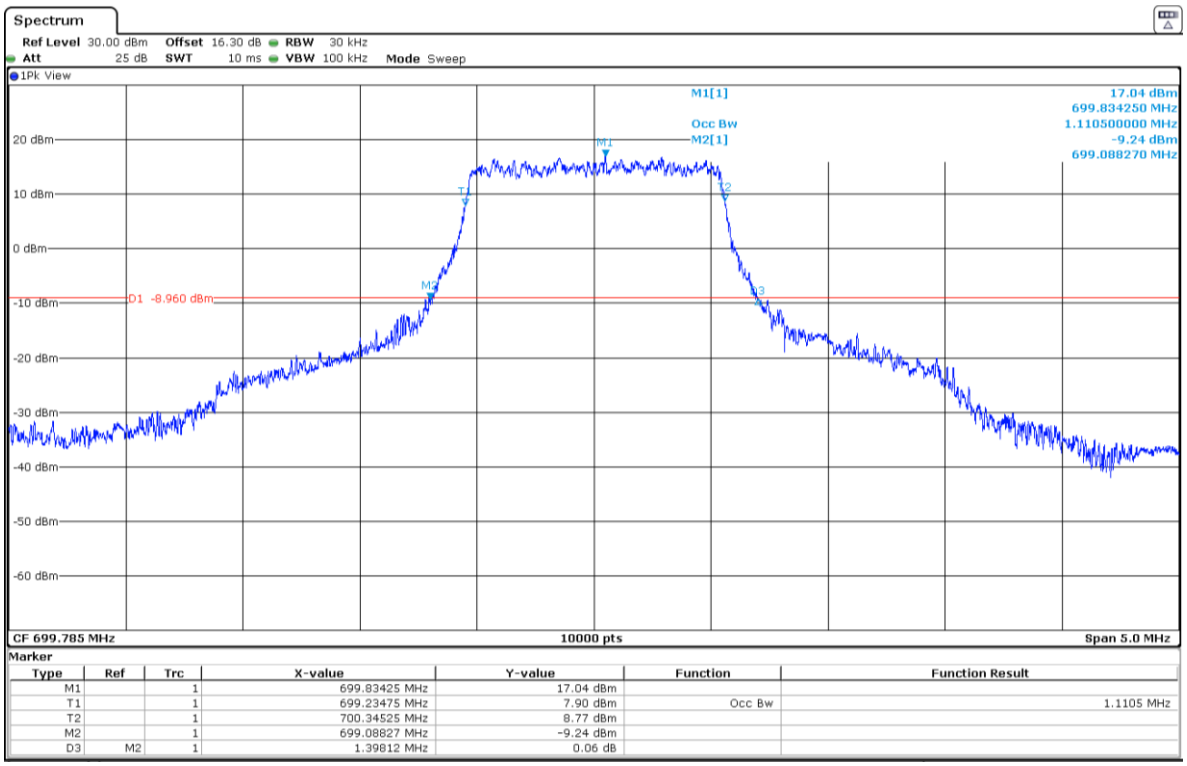
Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	1.1110	1.1100	1.1080
-26 dBc Bandwidth (MHz)	1.42095	1.41234	1.41837
Measurement uncertainty (kHz)	<±3.75		

16QAM. Nominal Bandwidth 5 MHz. Narrow band = 0, Position 1.

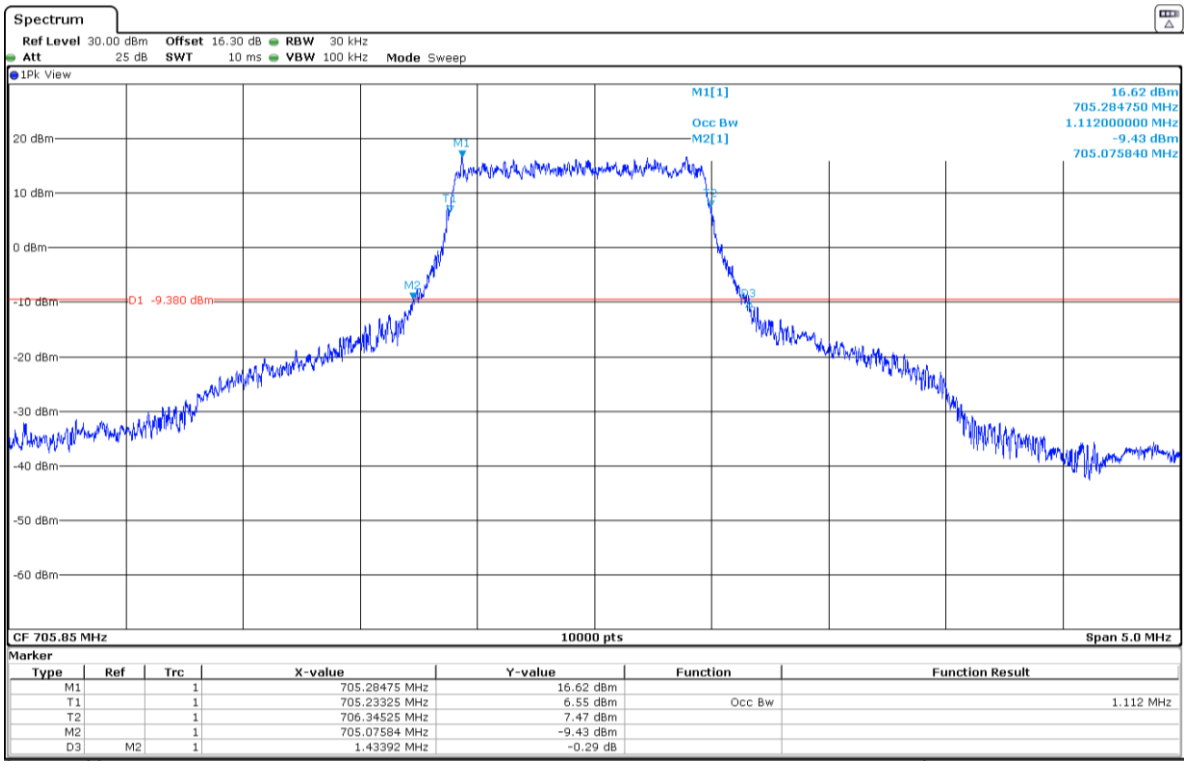
Channel	Low	Middle	High
99% Occupied Bandwidth (MHz)	0.9630	0.9455	0.9505
-26 dBc Bandwidth (MHz)	1.38804	1.35057	1.39910
Measurement uncertainty (kHz)	<±3.75		

LTE Band 12. QPSK. Nominal Bandwidth 5 MHz. Narrow band = 0. Position 1.

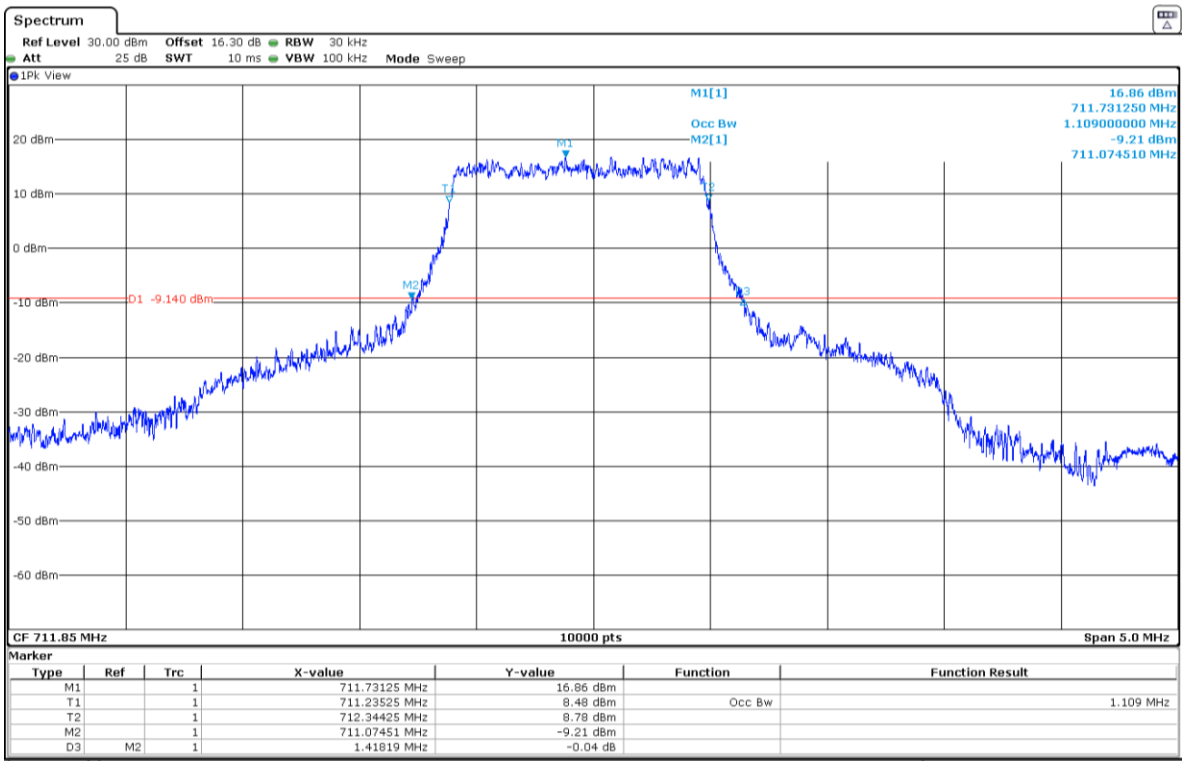
Low Channel:



Middle Channel:

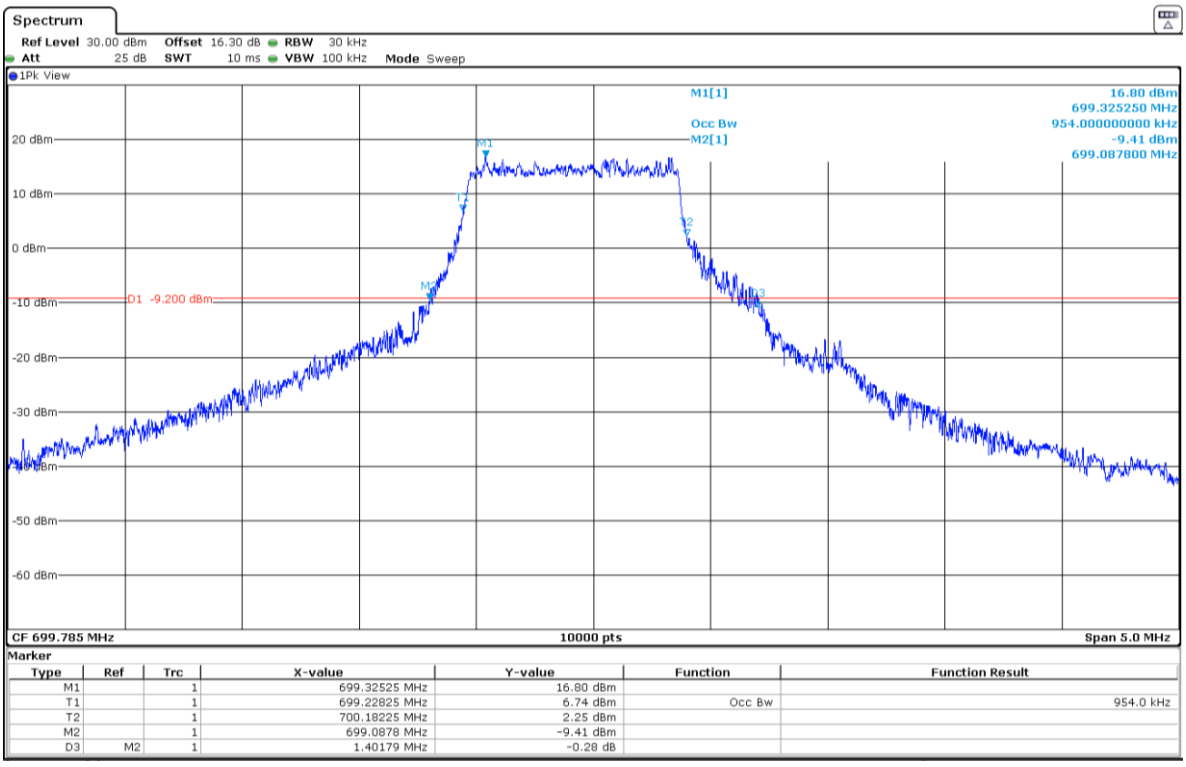


High Channel:

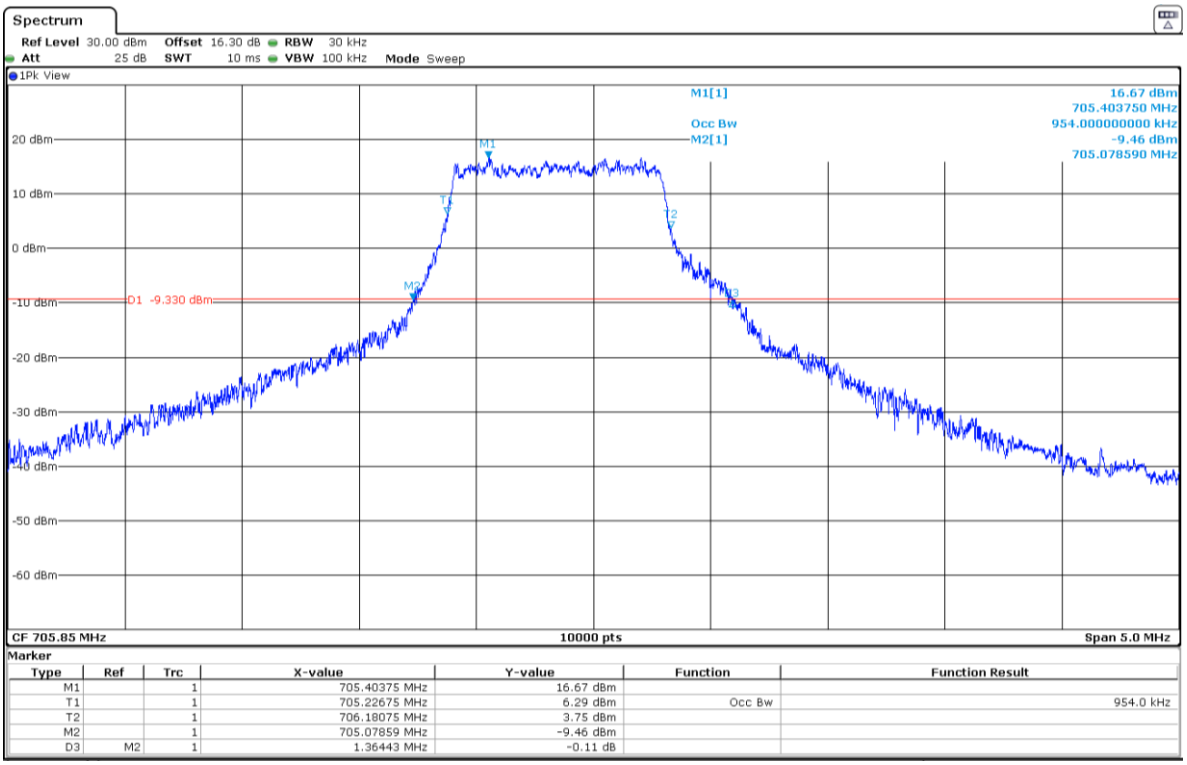


LTE Band 12. 16QAM. Nominal Bandwidth 5 MHz. Narrow band = 0. Position 1.

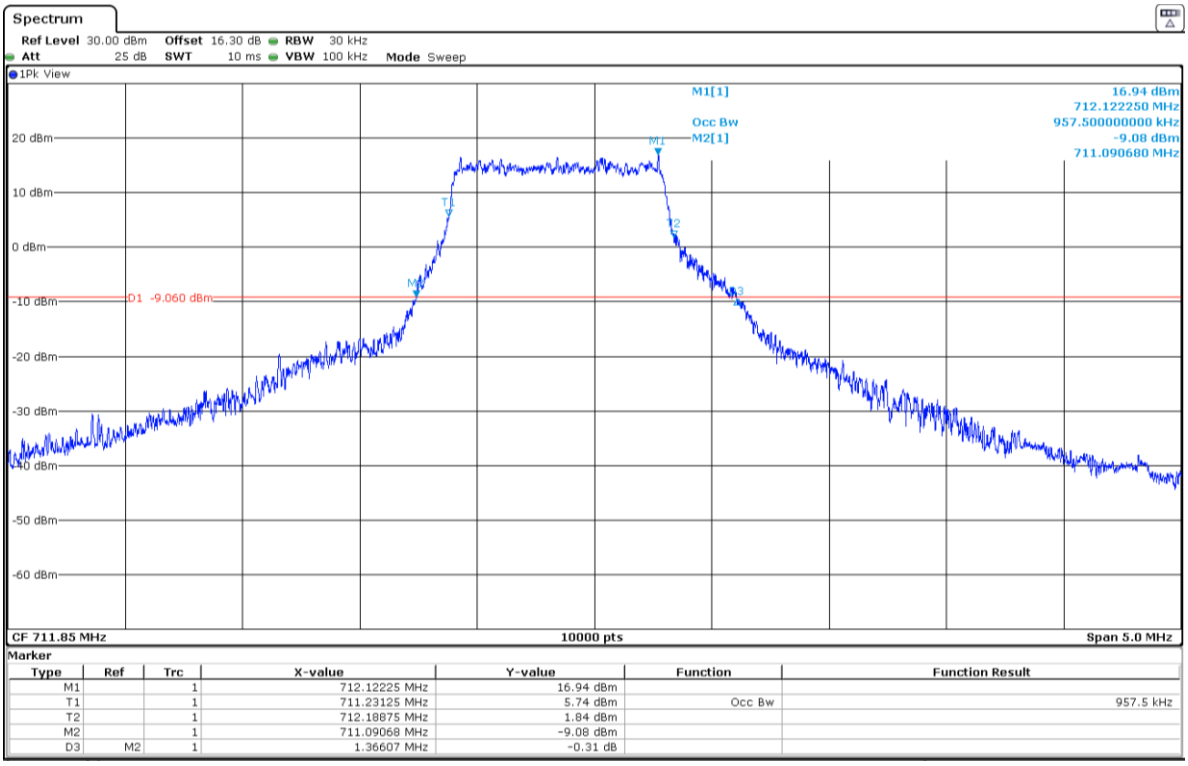
Low Channel:



Middle Channel:

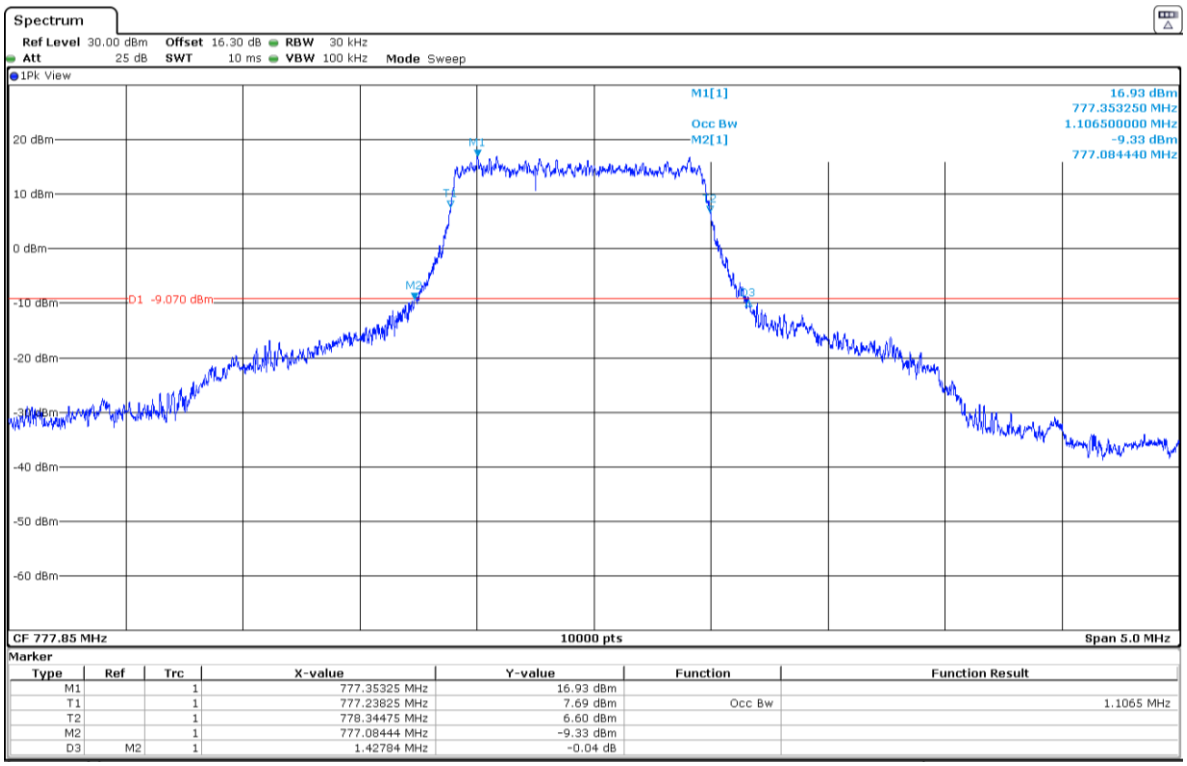


High Channel:

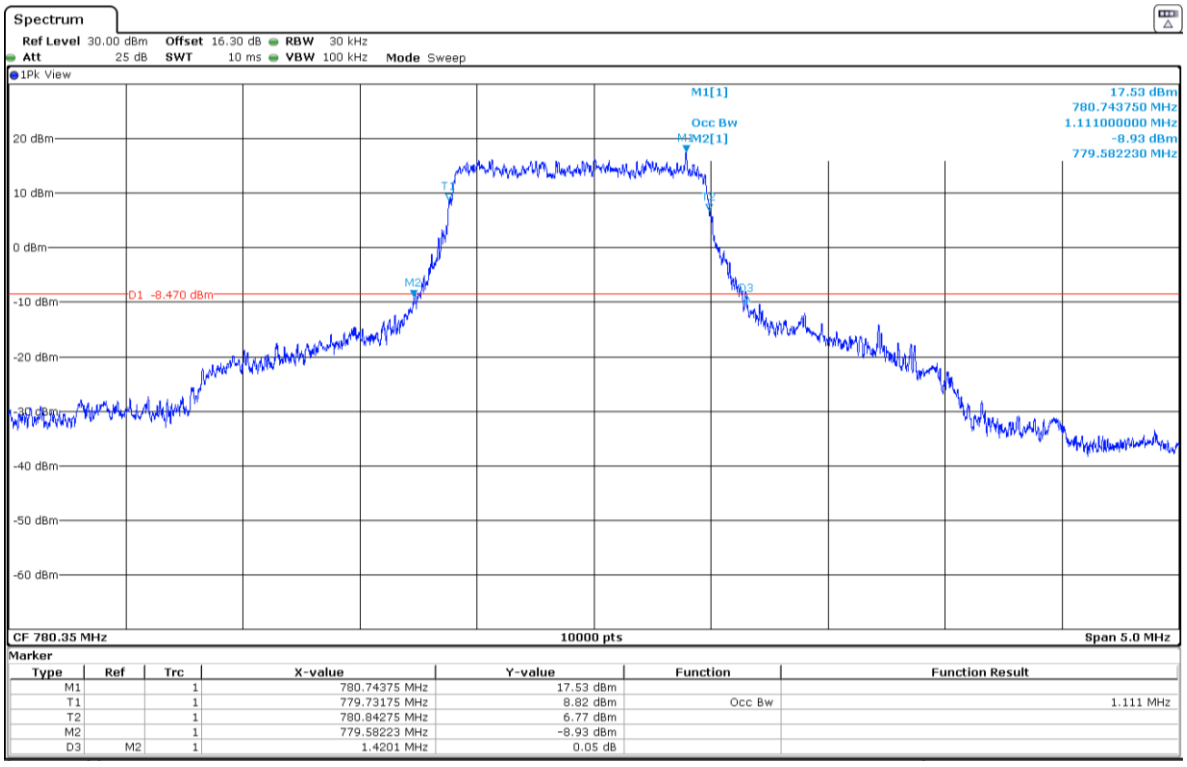


LTE Band 13. QPSK. Nominal Bandwidth 5 MHz. Narrow band = 0. Position 1.

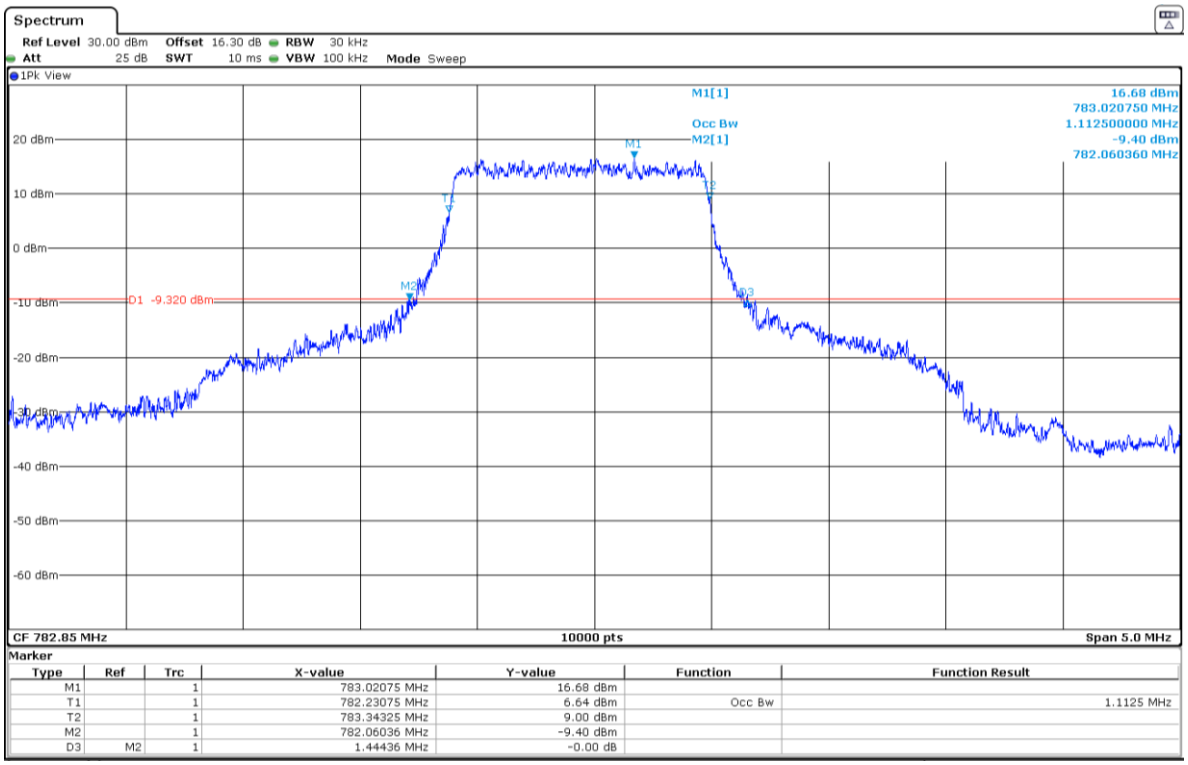
Low Channel:



Middle Channel:

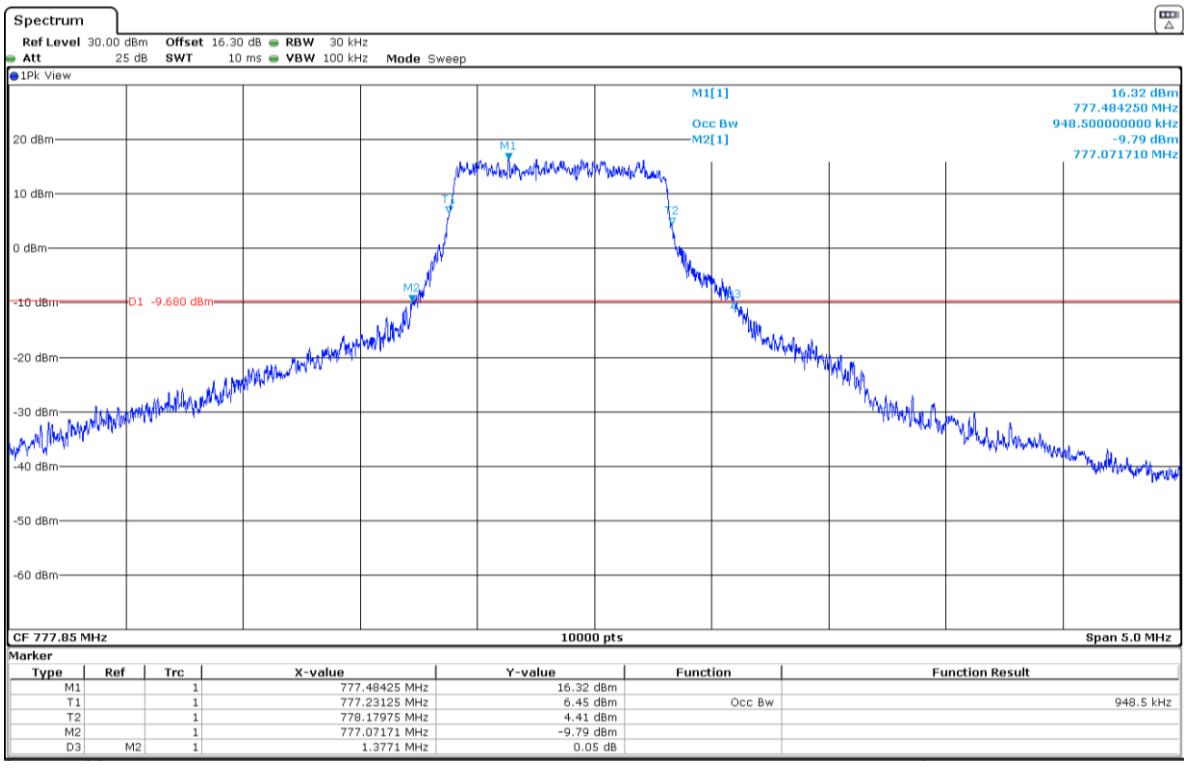


High Channel:

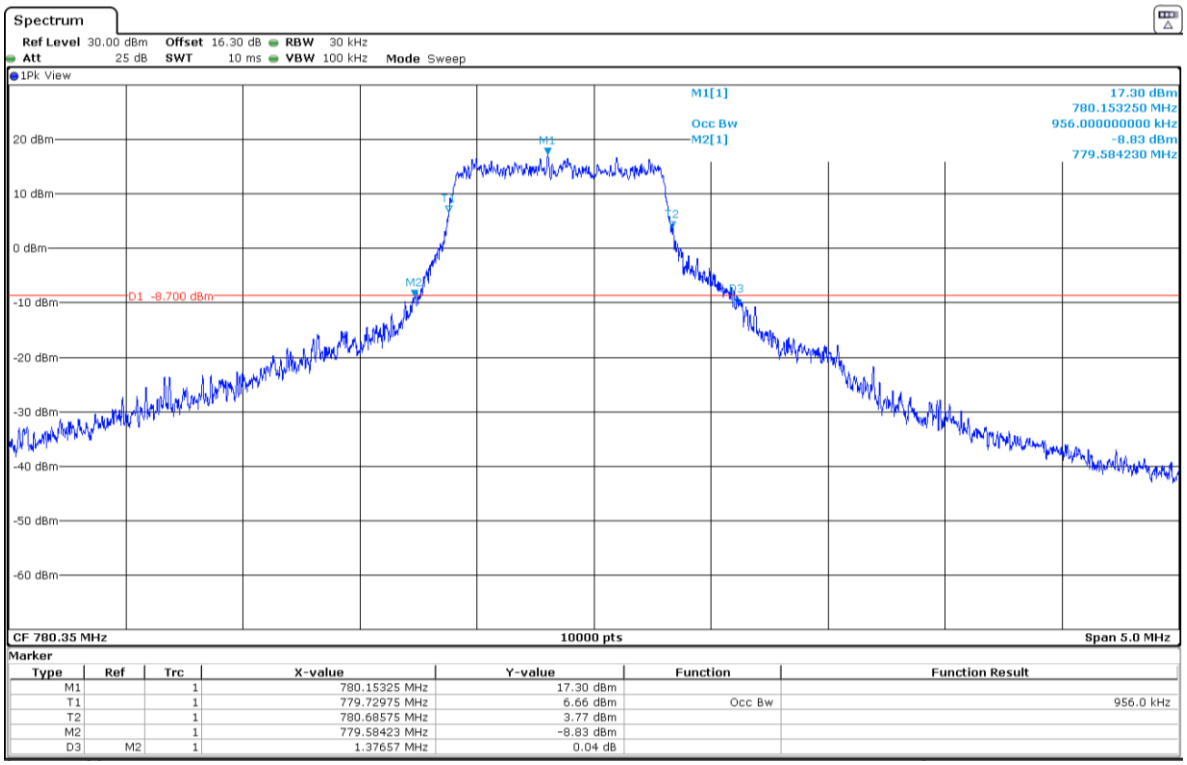


LTE Band 13. 16QAM. Nominal Bandwidth 5 MHz. Narrow band = 0. Position 1.

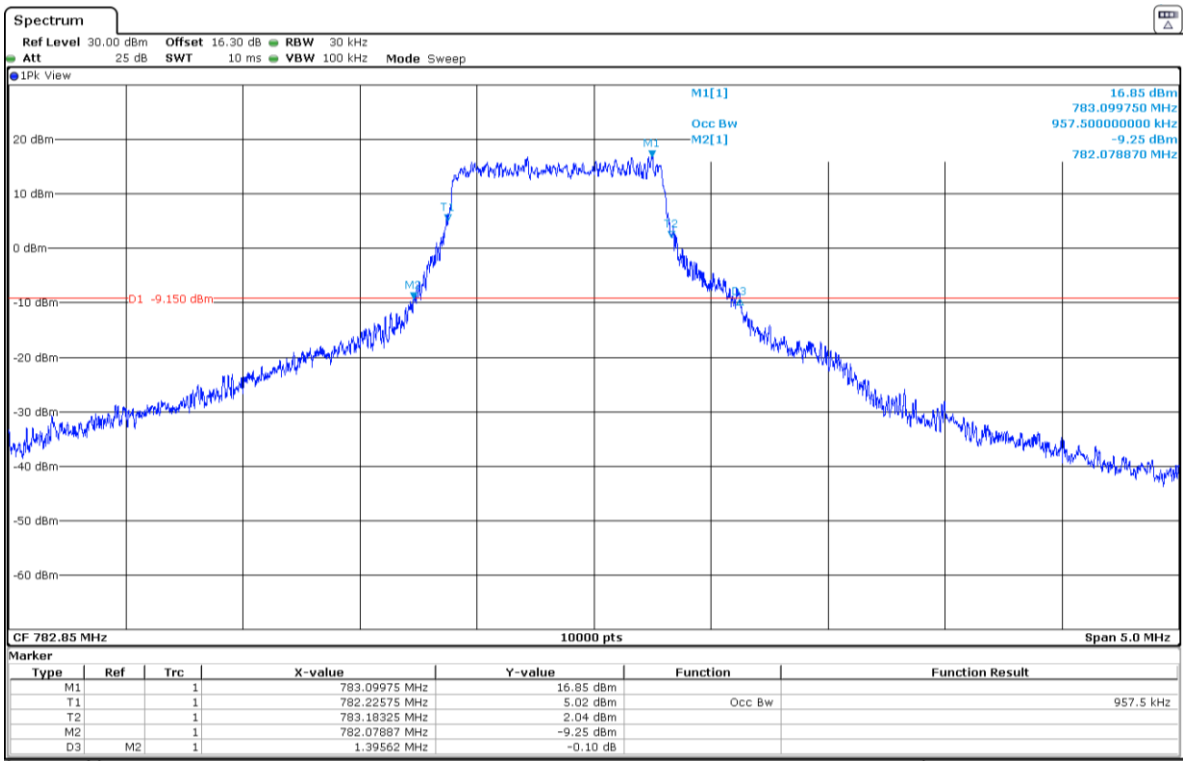
Low Channel:



Middle Channel:

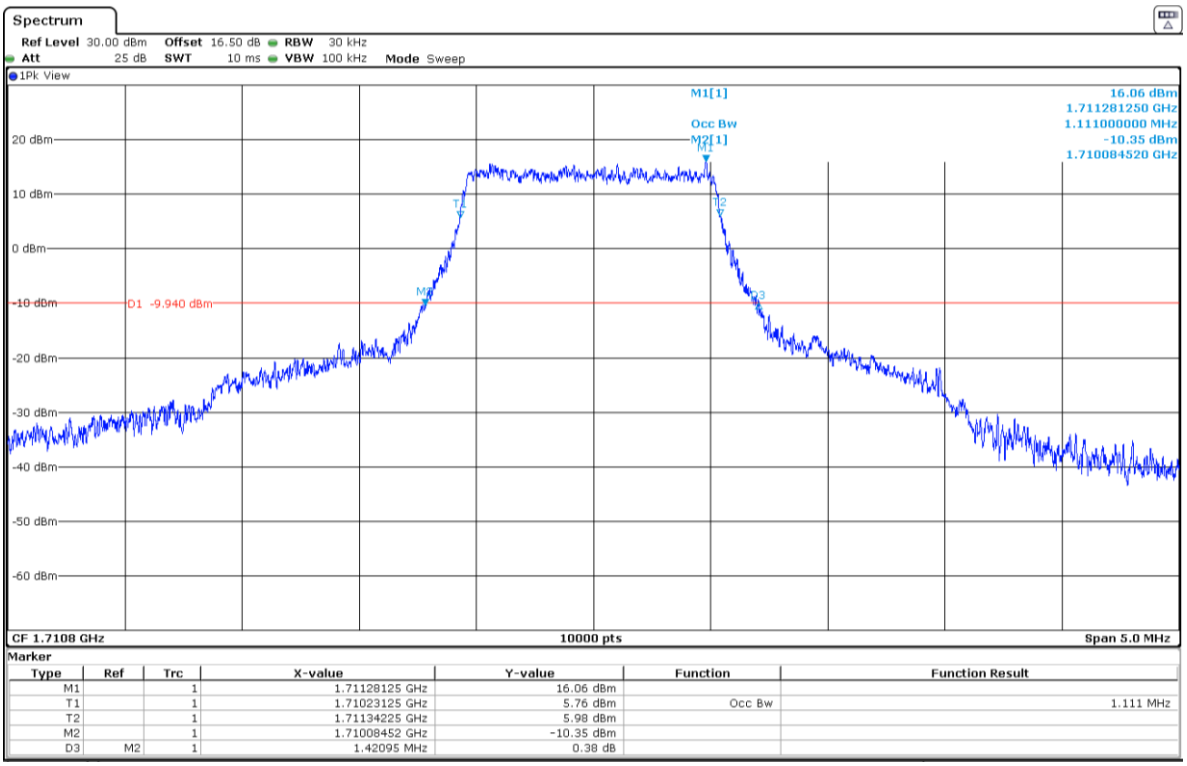


High Channel:

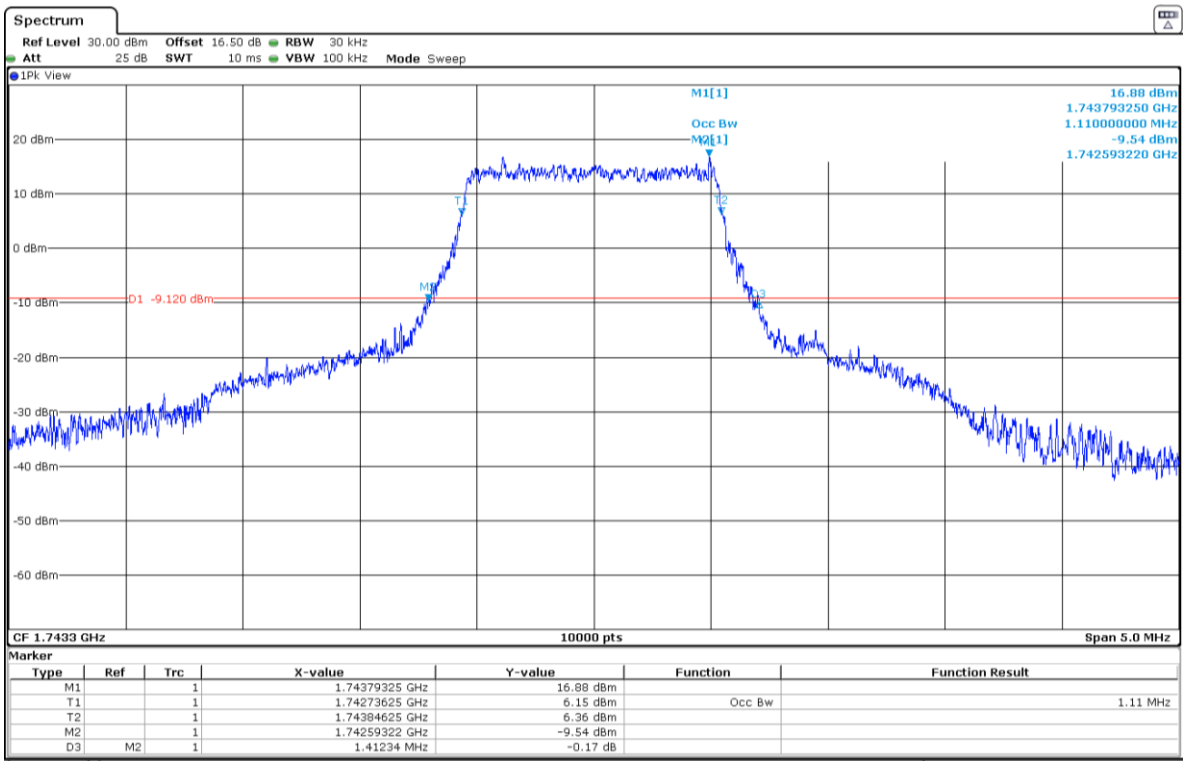


LTE Band 66. QPSK. Nominal Bandwidth 5 MHz. Narrow band = 0. Position 1.

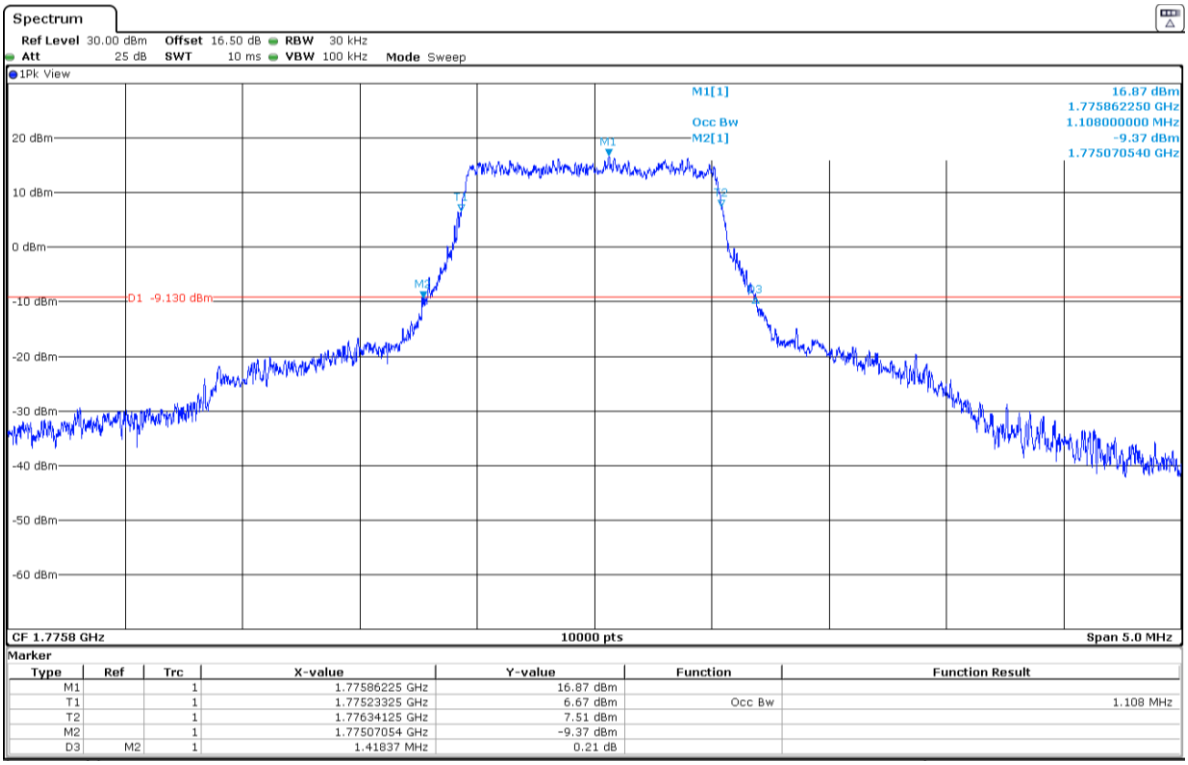
Low Channel:



Middle Channel:

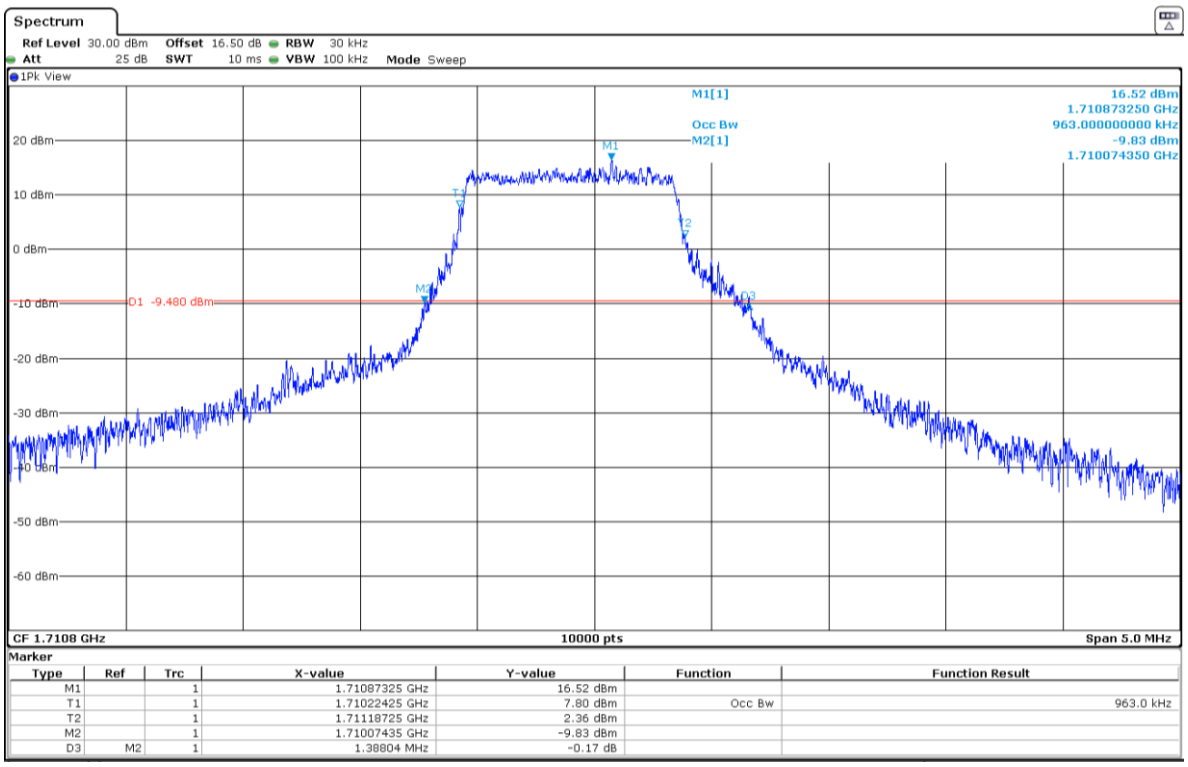


High Channel:

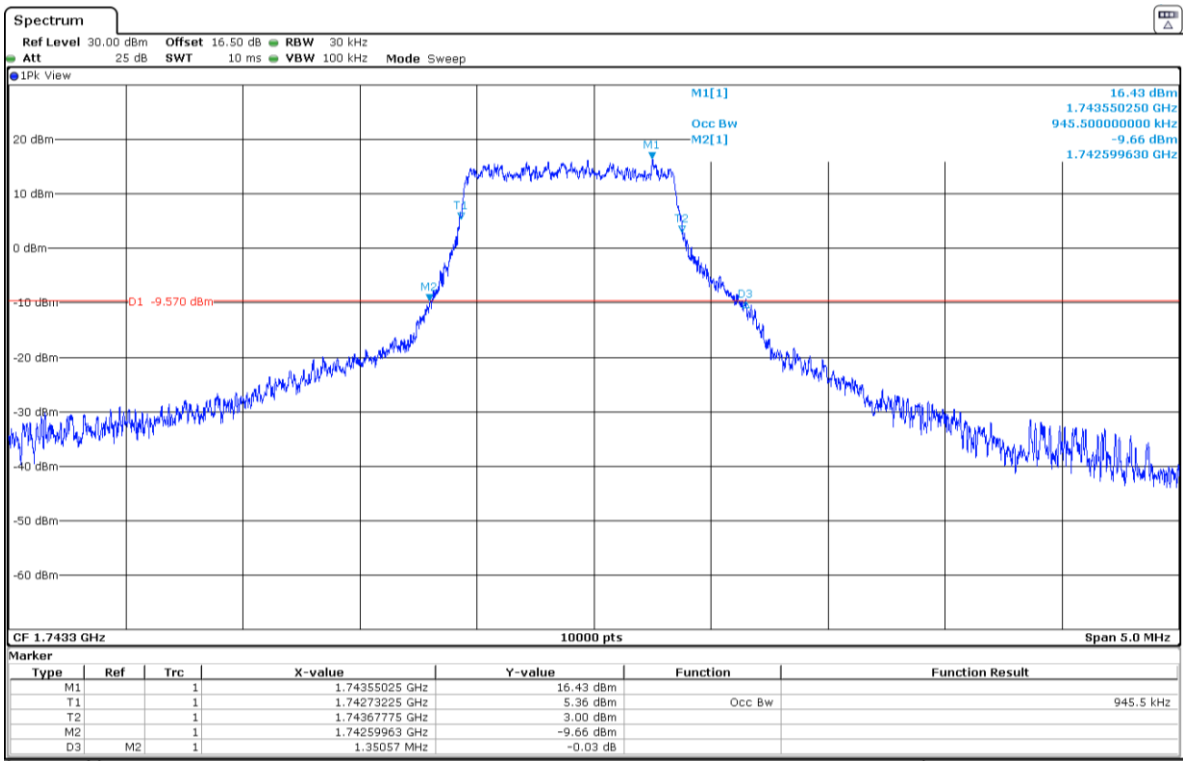


LTE Band 66. 16QAM. Nominal Bandwidth 5 MHz. Narrow band = 0. Position 1.

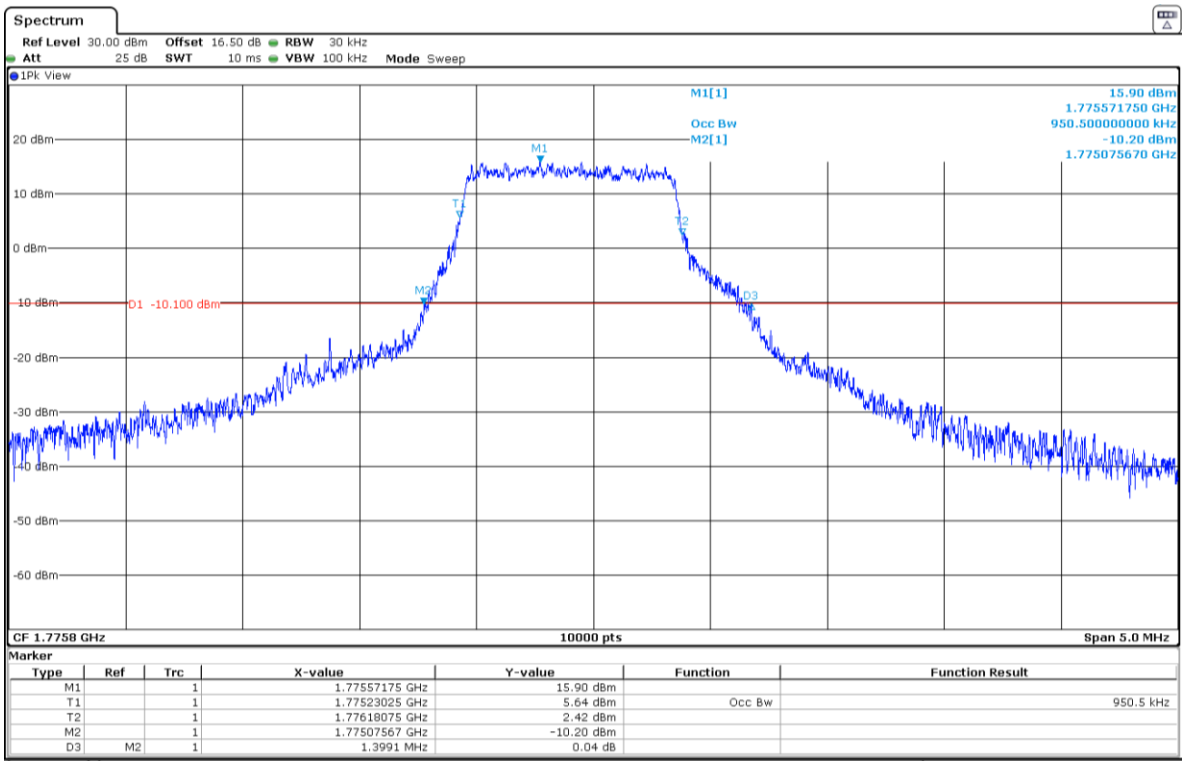
Low Channel:



Middle Channel:



High Channel:



Spurious Emissions at Antenna Terminals

SPECIFICATION

FCC §27.53 (c):

On any frequency outside the 776-788 MHz band, the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least 43 + 10 log (P) dB. Compliance is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kHz or greater.

On all frequencies between 763-775 MHz and 793-805 MHz, by a factor not less than 65 + 10 log (P) dB in a 6.25 kHz band segment, for mobile and portable stations. Compliance is based on the use of measurement instrumentation such that the reading taken with any resolution bandwidth setting should be adjusted to indicate spectral energy in a 6.25 kHz segment.

FCC §27.53 (g):

For operations in the 600 MHz band and the 698-746 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least 43 + 10 log (P) dB. Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kilohertz or greater.

RSS-130, Clause 4.7.1:

The unwanted emissions in any 100 kHz bandwidth on any frequency outside the low frequency edge and the high frequency edge of each frequency block range(s), shall be attenuated below the transmitter power, P (dBW), by at least 43 + 10 $\log_{10}$ p (watts), dB.

RSS-130, Clause 4.7.2:

The power of any unwanted emissions in any 6.25 kHz bandwidth for all frequencies between 763-775 MHz and 793-806 MHz shall be attenuated below the transmitter power, P (dBW), by at least 65 + 10 $\log_{10}$ p(watts), dB, for mobile and portable equipment.

FCC §27.53 (h), RSS-139, Clause 6.6:

According to specification, for operations in the 1695-1710 MHz, 1710-1755 MHz, 1755-1780 MHz, 1915-1920 MHz, 1995-2000 MHz, 2000-2020 MHz, 2110-2155 MHz, 2155-2180 MHz, and 2180-2200 bands, the power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) in watts by at least 43 + 10 log10 (P) dB.Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz 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

At Po transmitting power, the specified minimum attenuation becomes 65+10 log (Po), and the level in dBm relative to Po becomes:

Po (dBm) – [65 + 10 log (Po in mW) - 30] = -35 dBm

METHOD

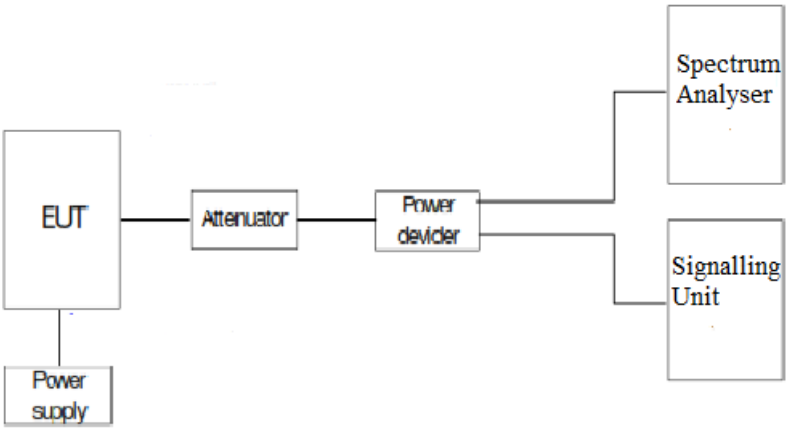
The EUT RF output connector was connected to a spectrum analyser and to the Universal Radio Communication tester R&S CMW500 (selecting maximum transmission power of the EUT and different modes of modulation) using a 50-Ohm attenuator and a power divider.

The spectrum was investigated from 9 kHz to 8 GHz for LTE Bands 12 & 13 and from 9 kHz to 18 GHz for LTE Band 66.

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

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

TEST SETUP



RESULTS (see plots in next pages)

LTE Band 12: QPSK. Nominal Bandwidth 5 MHz. RB Size 1, RB Offset 0. Narrow band = 0, Position 1.

- Low Channel: Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Limitations Conducted (dBm)
2098.539	-29.07

- Middle Channel: No spurious frequencies at less than 20 dB below the limit.

- High Channel: Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Limitations Conducted (dBm)
2133.469	-29.66

LTE Band 13: QPSK. Nominal Bandwidth 5 MHz. RB Size 1, RB Offset 0. Narrow band = 0, Position 1.

- Low Channel: Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Limitations Conducted (dBm)	Limit (dBm)
774.874	-46.58	-35
2332.939	-32.44	-13
6218.799	-31.20	

- Middle Channel: Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Limitations Conducted (dBm)	Limit (dBm)
2339.869	-32.39	-13
6238.799	-32.53	

- High Channel: No spurious frequencies at less than 20 dB below the limit.

LTE Band 66: QPSK. Nominal Bandwidth 20 MHz. RB Size 1, RB Offset 0. Narrow band = 0, Position 1.

- Low Channel: Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Limitations Conducted (dBm)
8557.509	-32.22

- Middle Channel: Spurious frequencies at less than 20 dB below the limit:

Spurious Frequency (MHz)	Emission Limitations Conducted (dBm)
8768.709	-30.17

- High Channel: Spurious frequencies at less than 20 dB below the limit:

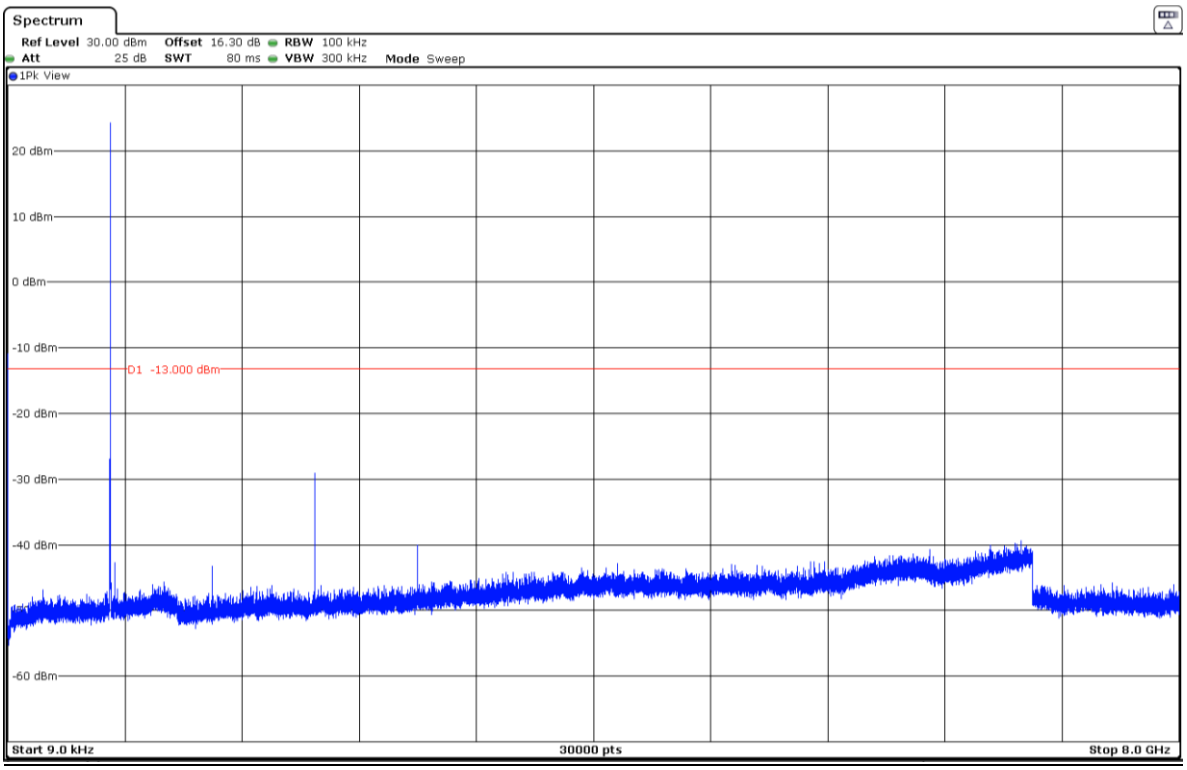
Spurious Frequency (MHz)	Emission Limitations Conducted (dBm)
5337.539	-31.12

Measurement uncertainty (dB): <±2.76

Verdict: PASS

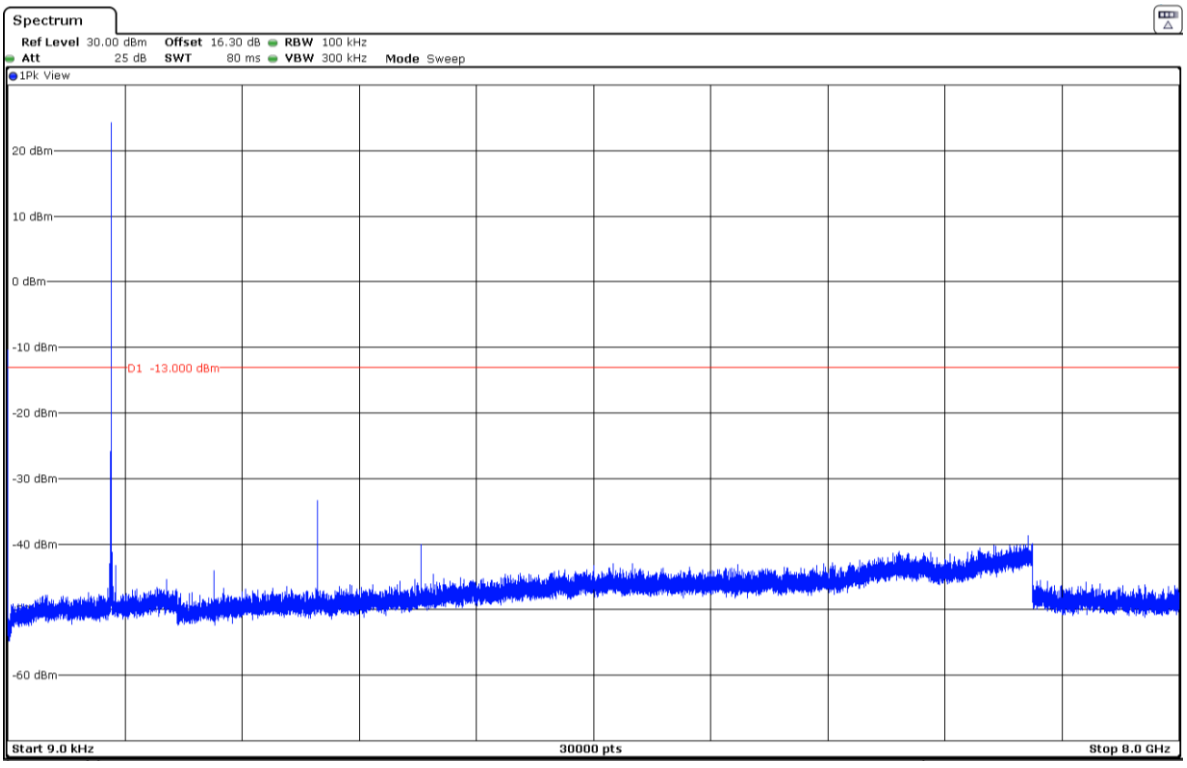
LTE Band 12. QPSK. Nominal Bandwidth 5 MHz. RB Size 1, RB Offset 0. Narrow band = 0, Position 1.

Low Channel:



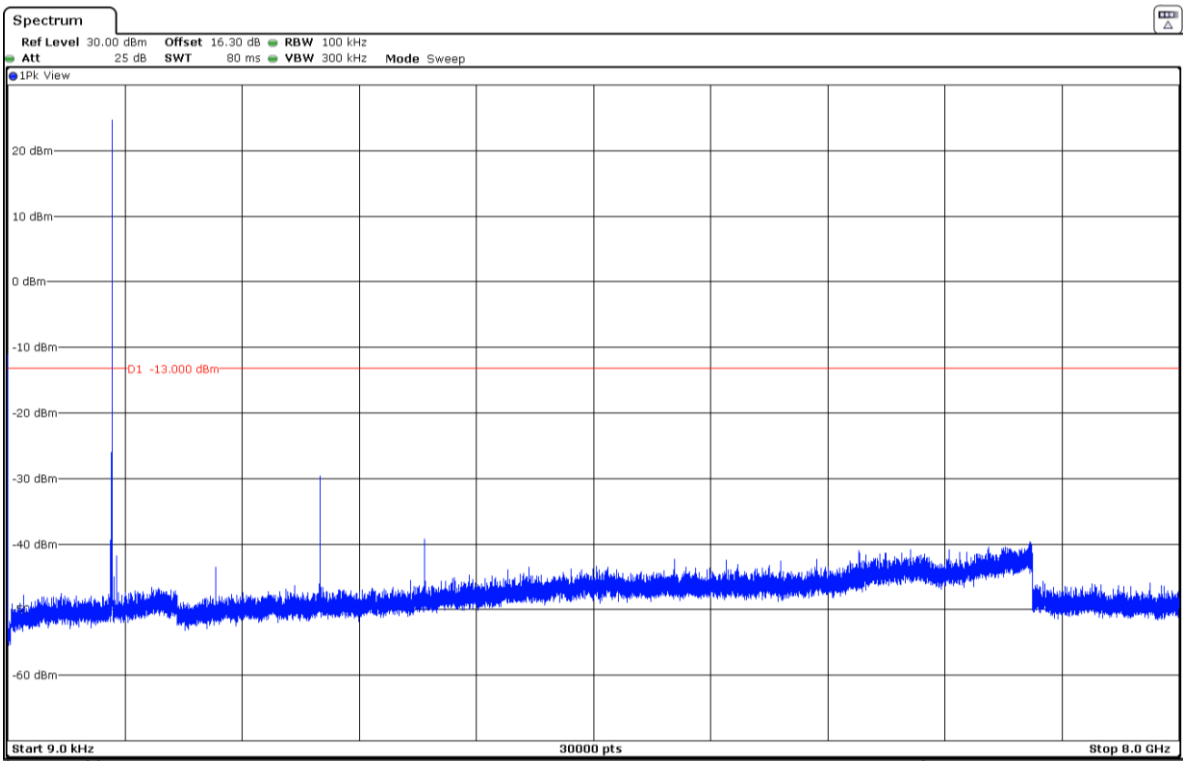
The peak above the limit is the carrier frequency.

Middle Channel:



The peak above the limit is the carrier frequency.

High Channel:

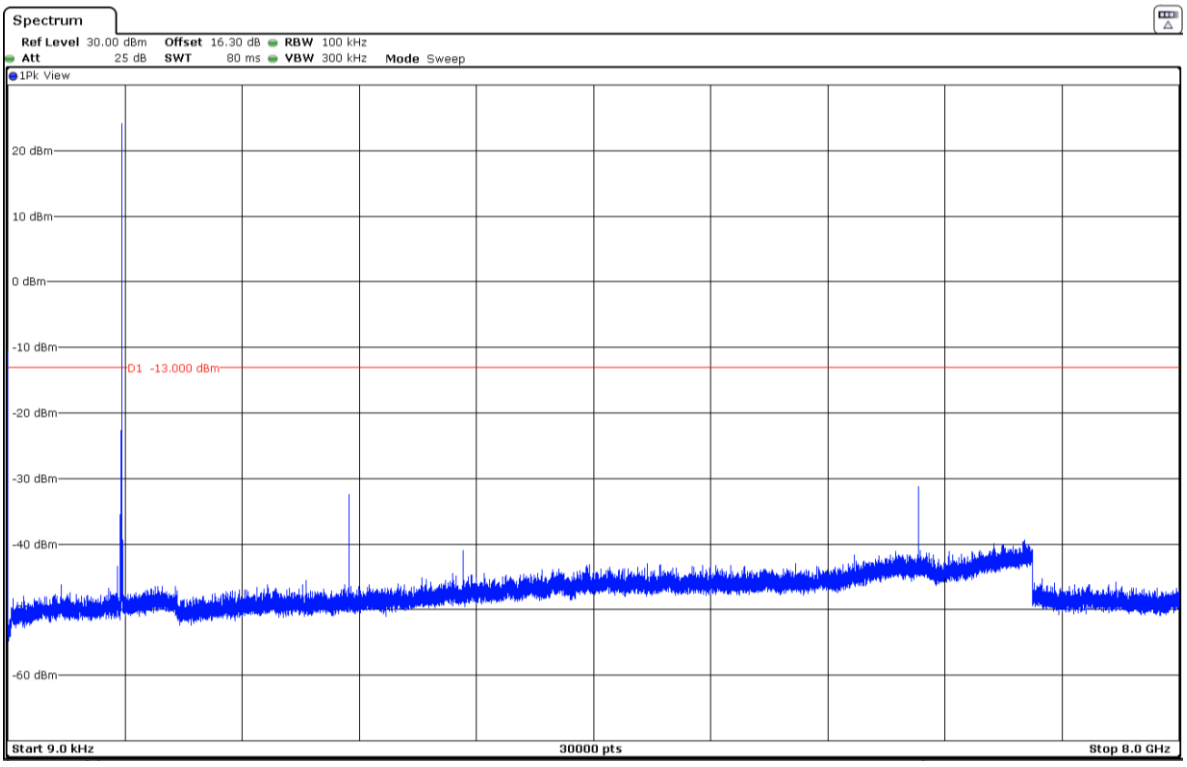


The peak above the limit is the carrier frequency.

LTE Band 13. QPSK. Nominal Bandwidth 5 MHz. RB Size 1, RB Offset 0. Narrow band = 0, Position 1.

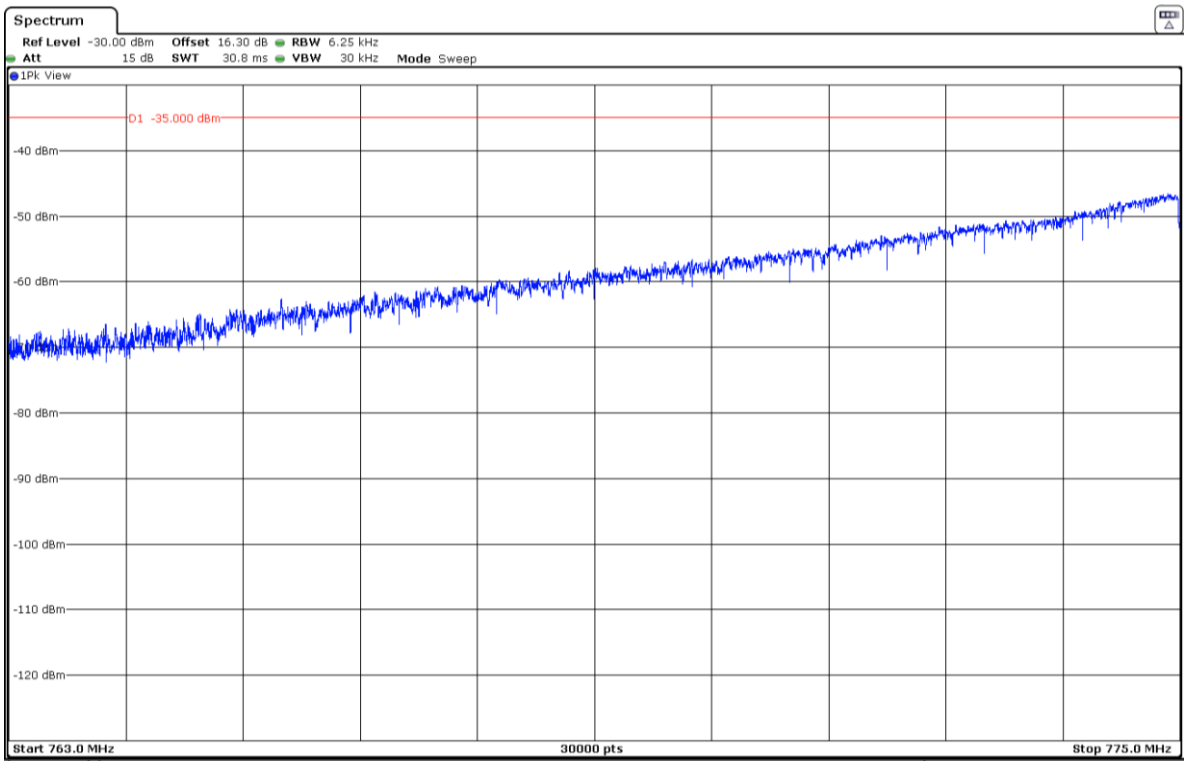
Low Channel:

- Frequency range 9 kHz – 8 GHz:

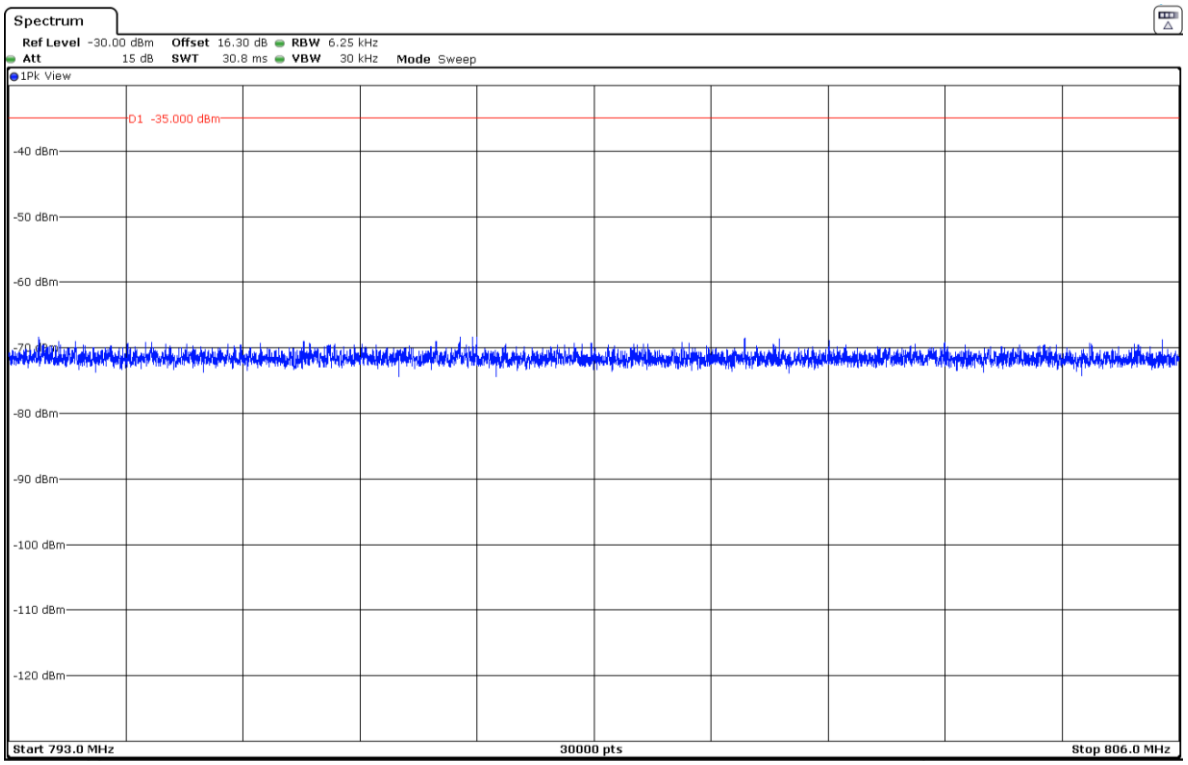


The peak above the limit is the carrier frequency.

- Frequency range 763 MHz – 775 MHz:

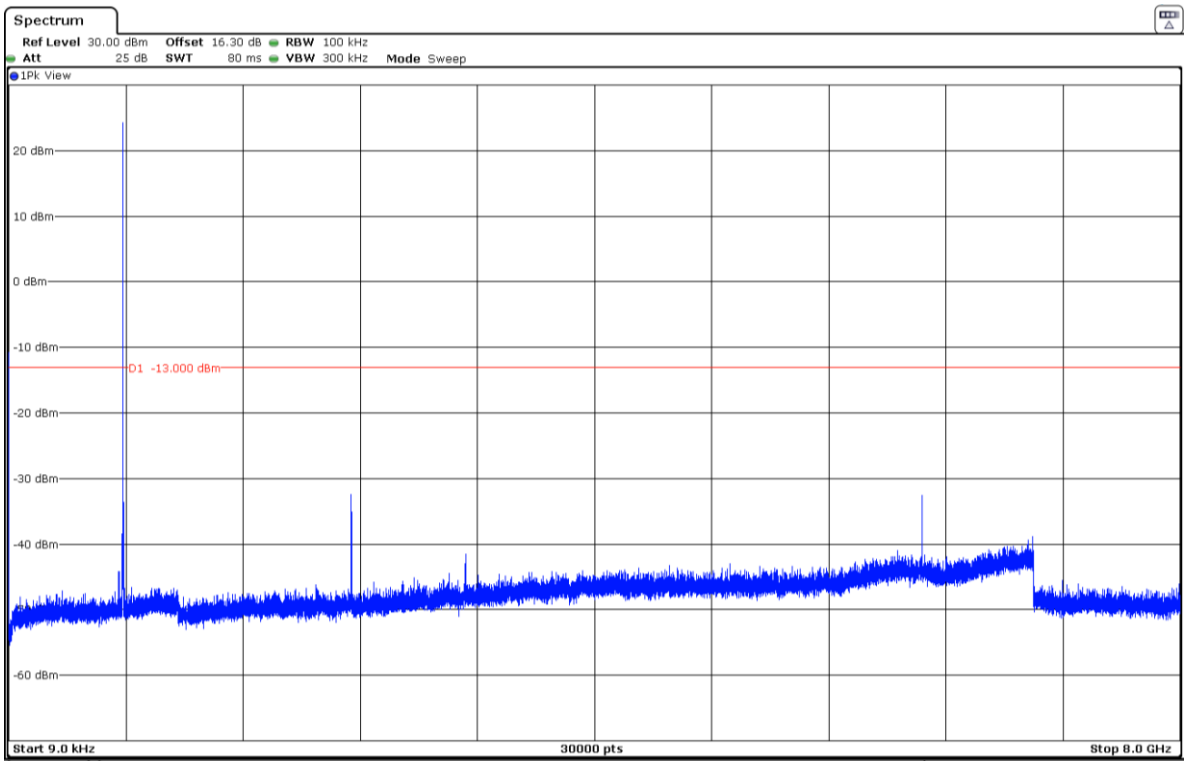


- Frequency range 793 MHz – 806 MHz:



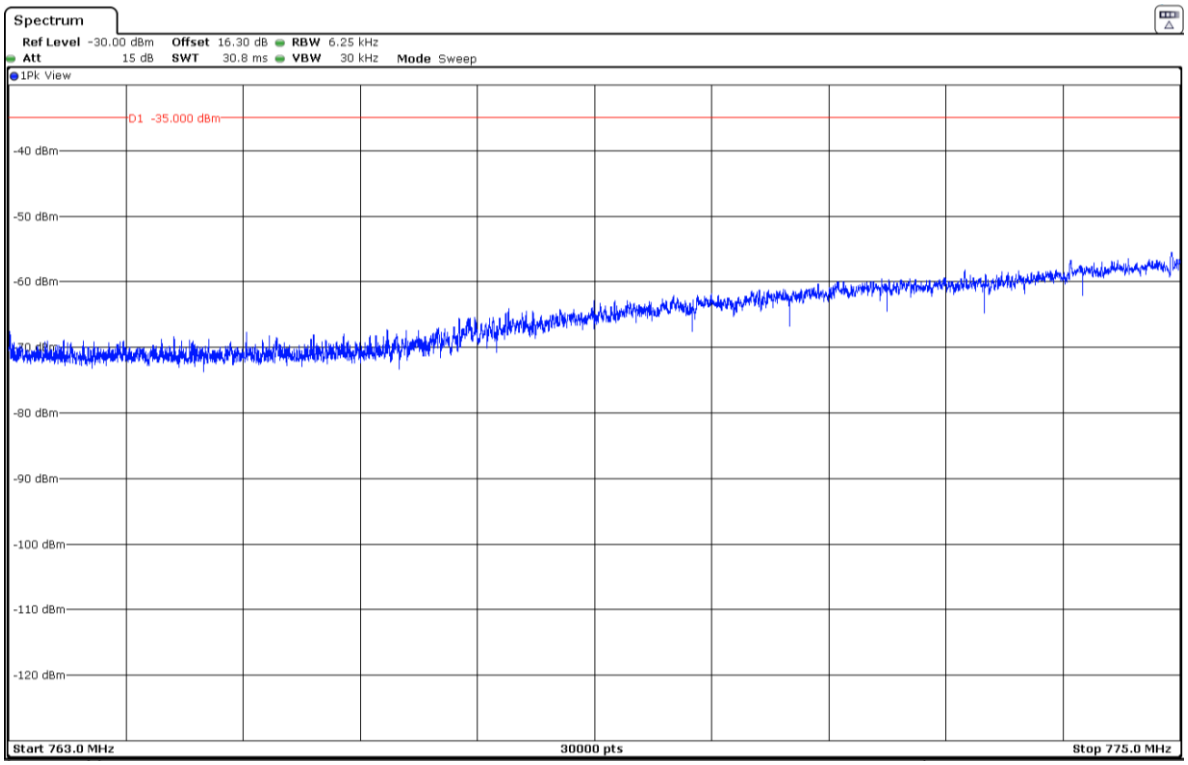
Middle Channel:

- Frequency range 9 kHz – 8 GHz:

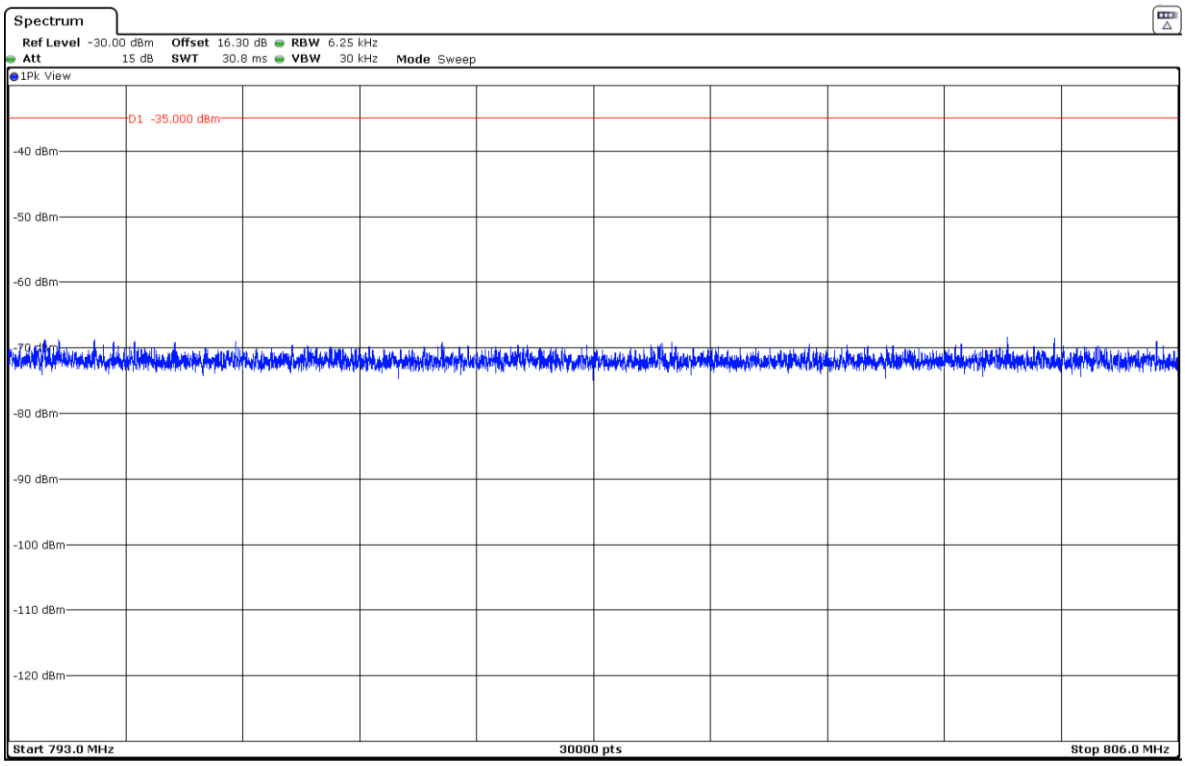


The peak above the limit is the carrier frequency.

- Frequency range 763 MHz – 775 MHz:

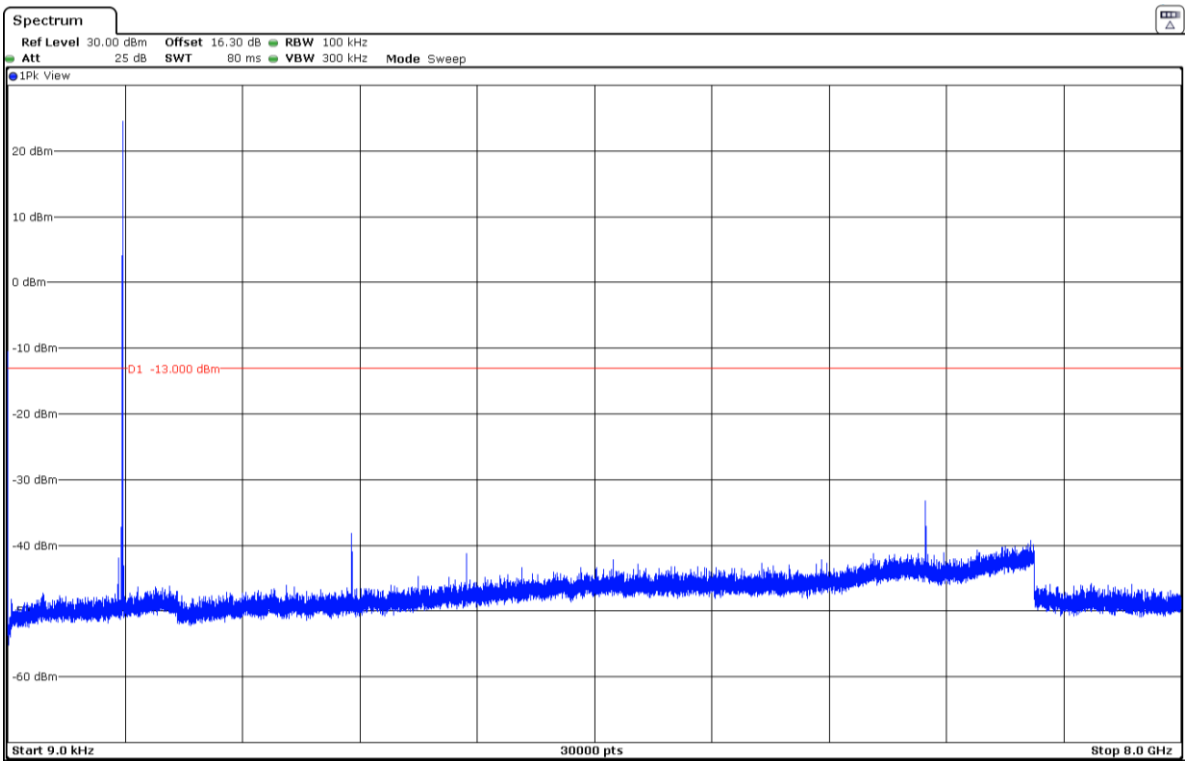


- Frequency range 793 MHz – 806 MHz:



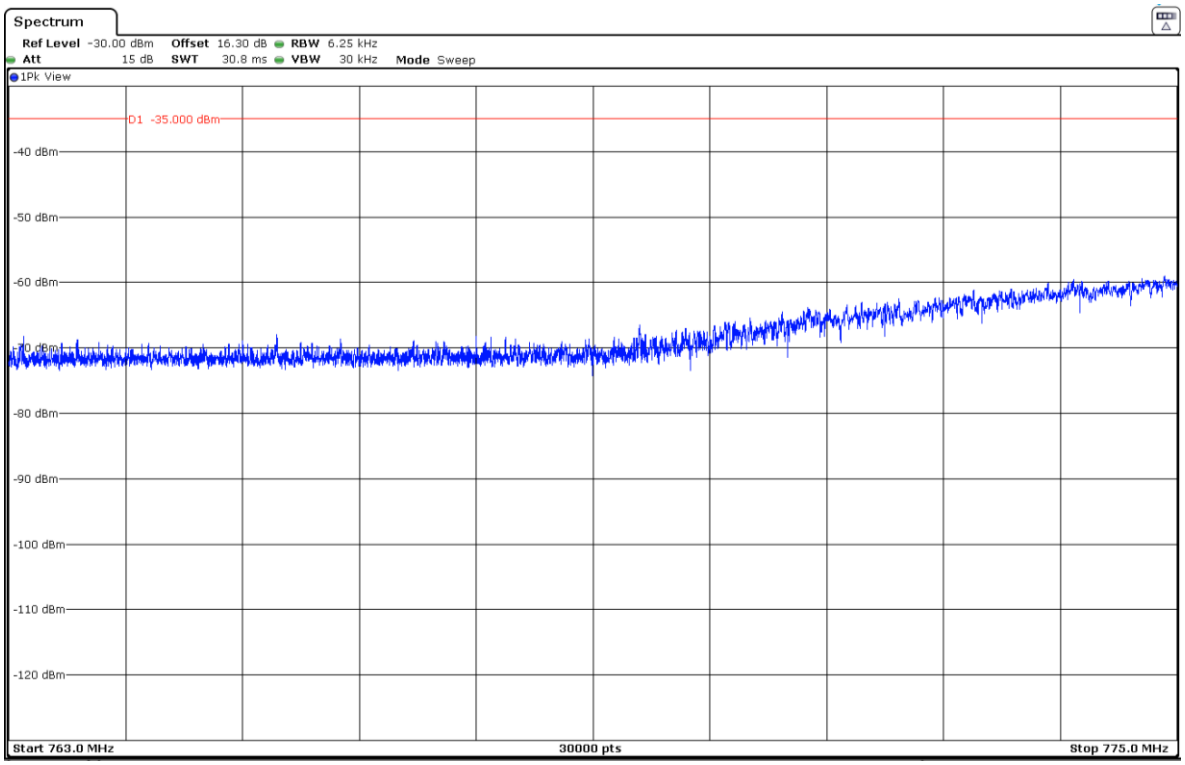
High Channel:

- Frequency range 9 kHz – 8 GHz:

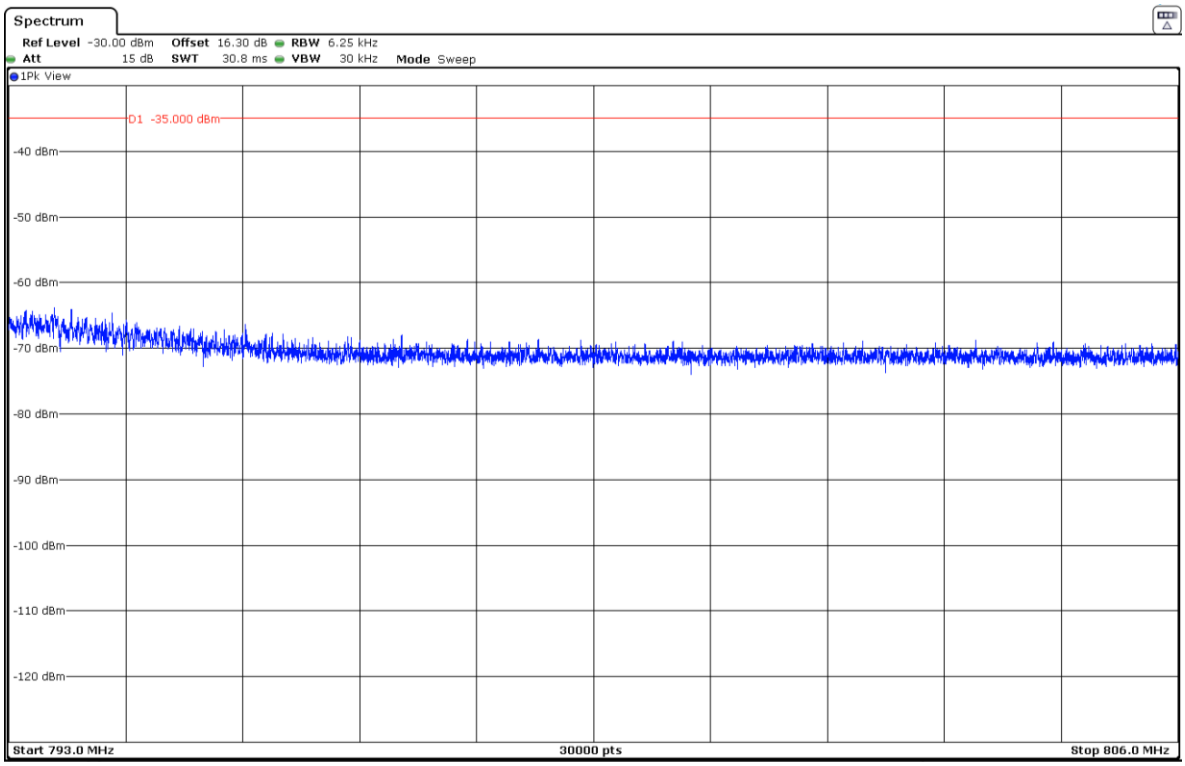


The peak above the limit is the carrier frequency.

- Frequency range 763 MHz – 775 MHz:

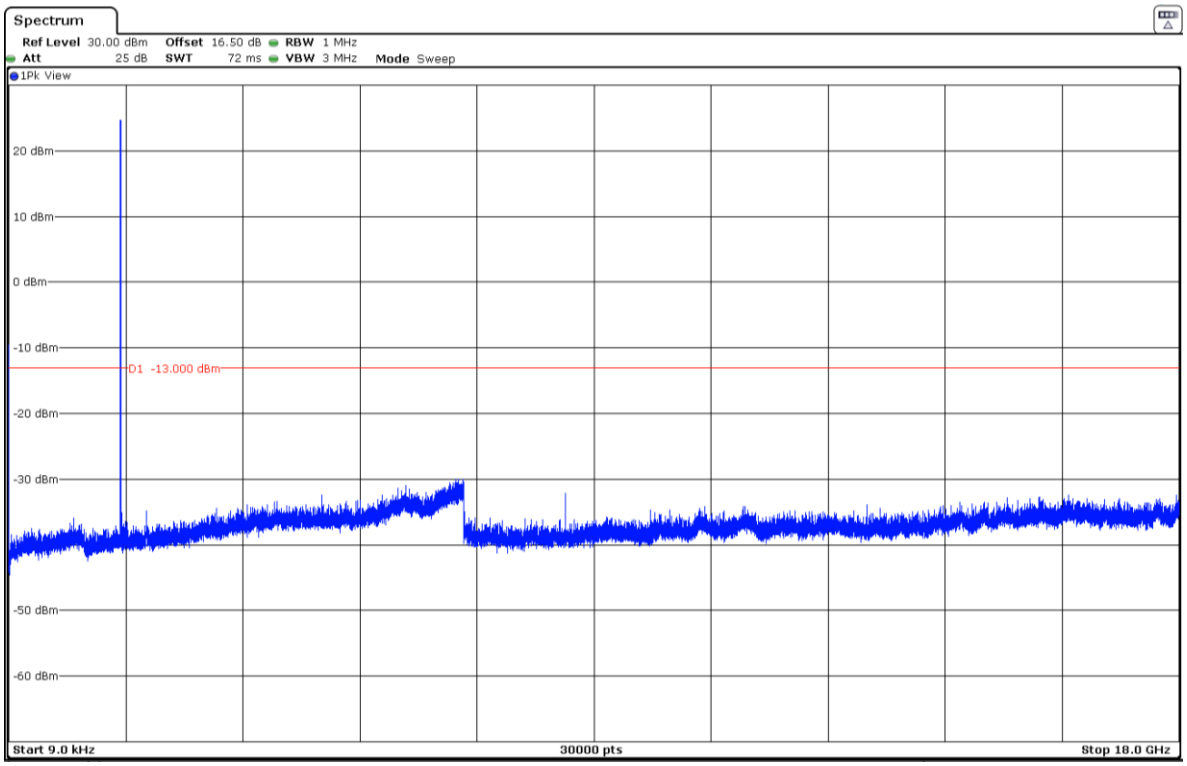


- Frequency range 793 MHz – 806 MHz:



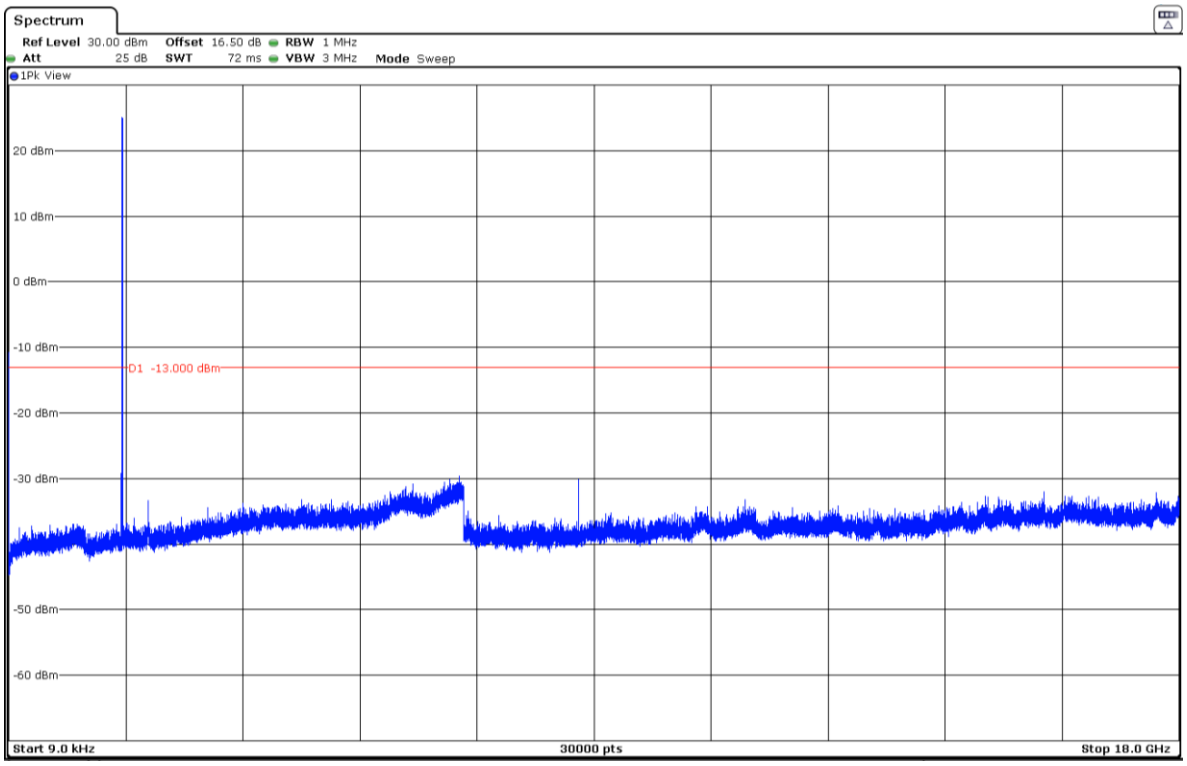
LTE Band 66. QPSK. Nominal Bandwidth 20 MHz. RB Size 1, RB Offset 0. Narrow band = 0, Position 1.

Low Channel:



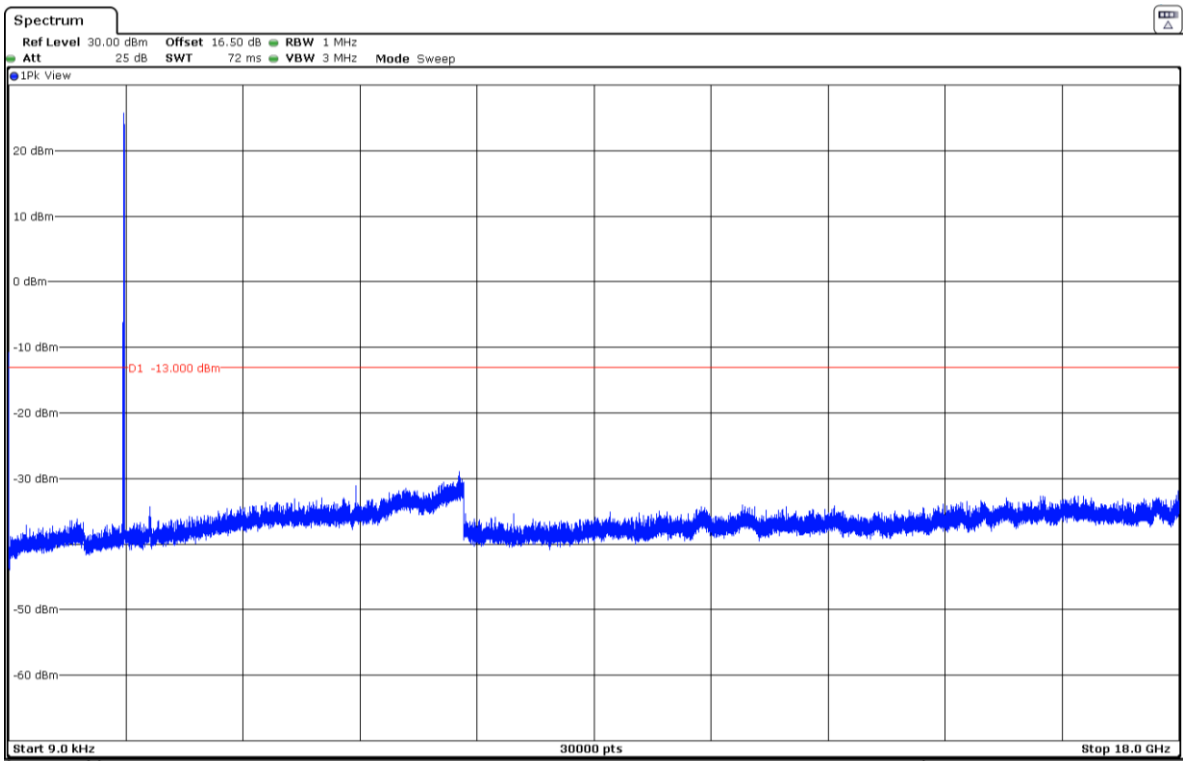
The peak above the limit is the carrier frequency.

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

SPECIFICATION

FCC §27.53 (c):

> On any frequency outside the 776-788 MHz band, the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least 43 + 10 log (P) dB.

FCC §27.53 (g):

> For operations in the 600 MHz band and the 698-746 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least 43 + 10 log (P) dB.

RSS-130 Clause 4.7.1:

> The unwanted emissions in any 100 kHz bandwidth on any frequency outside the low frequency edge and the high frequency edge of each frequency block range(s), shall be attenuated below the transmitter power, P (dBW), by at least 43 + 10 $\log_{10}$ p (watts), dB.

FCC §27.53 (h), RSS-139 Clause 6.6:

> According to specification, for operations in the 1695-1710 MHz, 1710-1755 MHz, 1755-1780 MHz, 1915-1920 MHz, 1995-2000 MHz, 2000-2020 MHz, 2110-2155 MHz, 2155-2180 MHz, and 2180-2200 bands, the power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) in watts by at least 43 + 10 $\log_{10}$ (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.

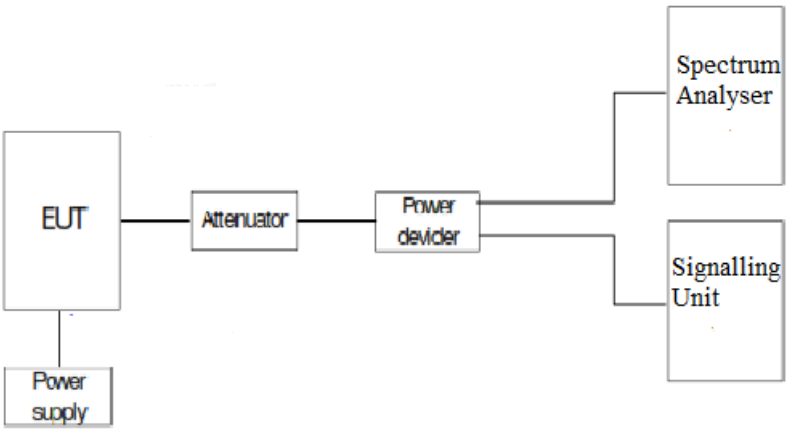
The configuration of modulation which is the worst case for conducted power was used.

For LTE Bands 4 and 66, as stated in FCC part 27.53 (h) (3) / RSS-139 Clause 6.6, in the 1 MHz bands immediately outside and adjacent to the licensee's frequency block, a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed.

For LTE Band 12, as stated in FCC part 27.53 (g) / RSS-130 Clause 4.7.1, in the 100 kHz bands immediately outside and adjacent to the licensee's frequency block or band, a resolution bandwidth of 30 kHz may be employed.

For LTE Band 13, as stated in FCC part 27.53 (c) (5) / RSS-130 Clause 4.7.1, in the 100 kHz bands immediately outside and adjacent to the frequency block, a resolution bandwidth of at least 30 kHz may be employed.

TEST SETUP



RESULTS (see plots in next pages)

LTE Band 4:

Preliminary measurements determined the Nominal Bandwidth of 5 MHz, QPSK modulation as the worst case. The next results are for this worst-case configuration.

LTE QPSK MODULATION	RB = 1 Offset = Max. BW = 5 MHz Narrow band = 3
Maximum measured level at High Block Edge at antenna port (dBm)	-20.01

LTE QPSK MODULATION	RB = All Offset = 0 BW = 5 MHz Narrow band = 3
Maximum measured level at High Block Edge at antenna port (dBm)	-24.10

LTE Band 12:

Preliminary measurements determined the Nominal Bandwidth of 5 MHz, QPSK modulation as the worst case. The next results are for this worst-case configuration.

LTE QPSK MODULATION	RB = 1 Offset = 0 BW = 5 MHz Narrow band = 0
Maximum measured level at Low Block Edge at antenna port (dBm)	-31.60

LTE QPSK MODULATION	RB = All Offset = 0 BW = 5 MHz Narrow band = 0
Maximum measured level at Low Block Edge at antenna port (dBm)	-31.49

LTE QPSK MODULATION	RB = 1 Offset = Max. BW = 5 MHz Narrow band = 3
Maximum measured level at High Block Edge at antenna port (dBm)	-21.19

LTE QPSK MODULATION	RB = All Offset = 0 BW = 5 MHz Narrow band = 3
Maximum measured level at High Block Edge at antenna port (dBm)	-16.83

LTE Band 13:

Preliminary measurements determined the Nominal Bandwidth of 5 MHz, QPSK modulation as the worst case. The next results are for this worst-case configuration.

LTE QPSK MODULATION	RB = 1 Offset = 0 BW = 5 MHz Narrow band = 0
Maximum measured level at Low Block Edge at antenna port (dBm)	-16.03

LTE QPSK MODULATION	RB = All Offset = 0 BW = 5 MHz Narrow band = 0
Maximum measured level at Low Block Edge at antenna port (dBm)	-17.86

LTE QPSK MODULATION	RB = 1 Offset = Max. BW = 5 MHz Narrow band = 3
Maximum measured level at High Block Edge at antenna port (dBm)	-18.30

LTE QPSK MODULATION	RB = All Offset = 0 BW = 5 MHz Narrow band = 3
Maximum measured level at High Block Edge at antenna port (dBm)	-17.16

LTE Band 66:

Preliminary measurements determined the Nominal Bandwidth of 5 MHz, QPSK modulation as the worst case. The next results are for this worst-case configuration.

LTE QPSK MODULATION	RB = 1 Offset = 0 BW = 5 MHz Narrow band = 0
Maximum measured level at Low Block Edge at antenna port (dBm)	-21.26

LTE QPSK MODULATION	RB = All Offset = 0 BW = 5 MHz Narrow band = 0
Maximum measured level at Low Block Edge at antenna port (dBm)	-25.29

LTE QPSK MODULATION	RB = 1 Offset = Max. BW = 5 MHz Narrow band = 3
Maximum measured level at High Block Edge at antenna port (dBm)	-19.29

LTE QPSK MODULATION	RB = All Offset = 0 BW = 5 MHz Narrow band = 3
Maximum measured level at High Block Edge at antenna port (dBm)	-24.08

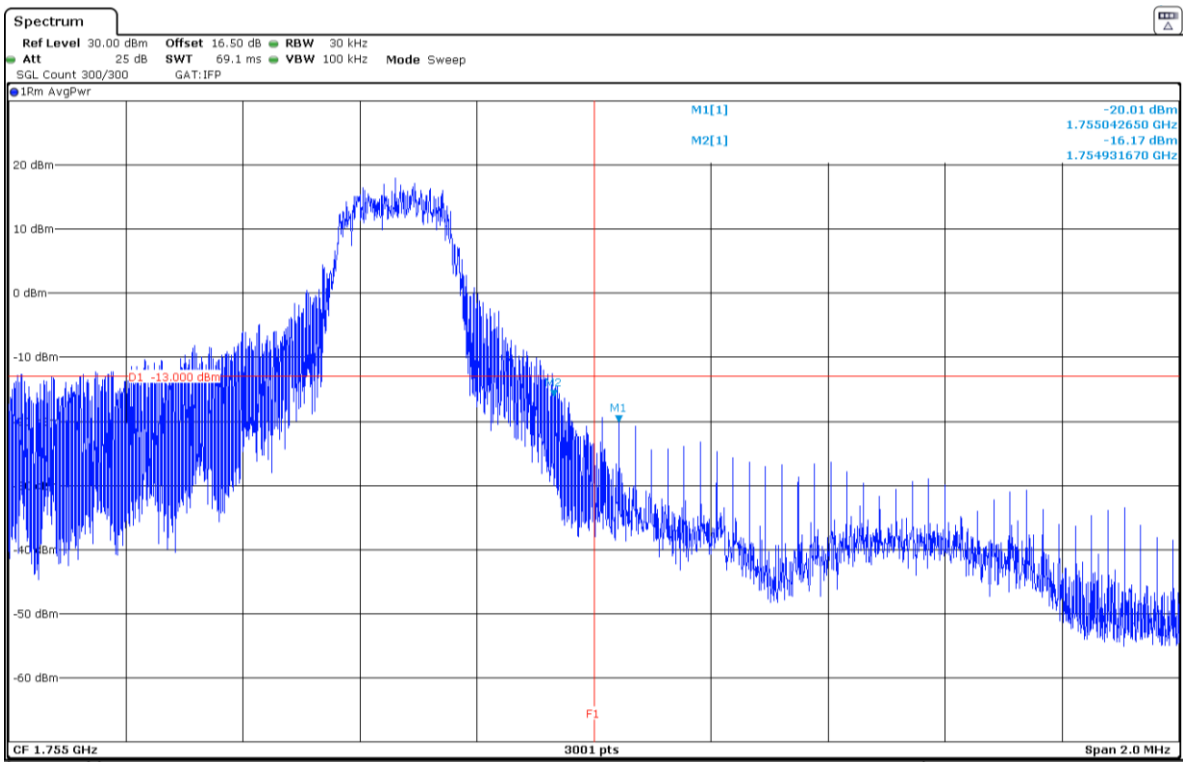
Measurement uncertainty (dB): <±2.76

Verdict: PASS

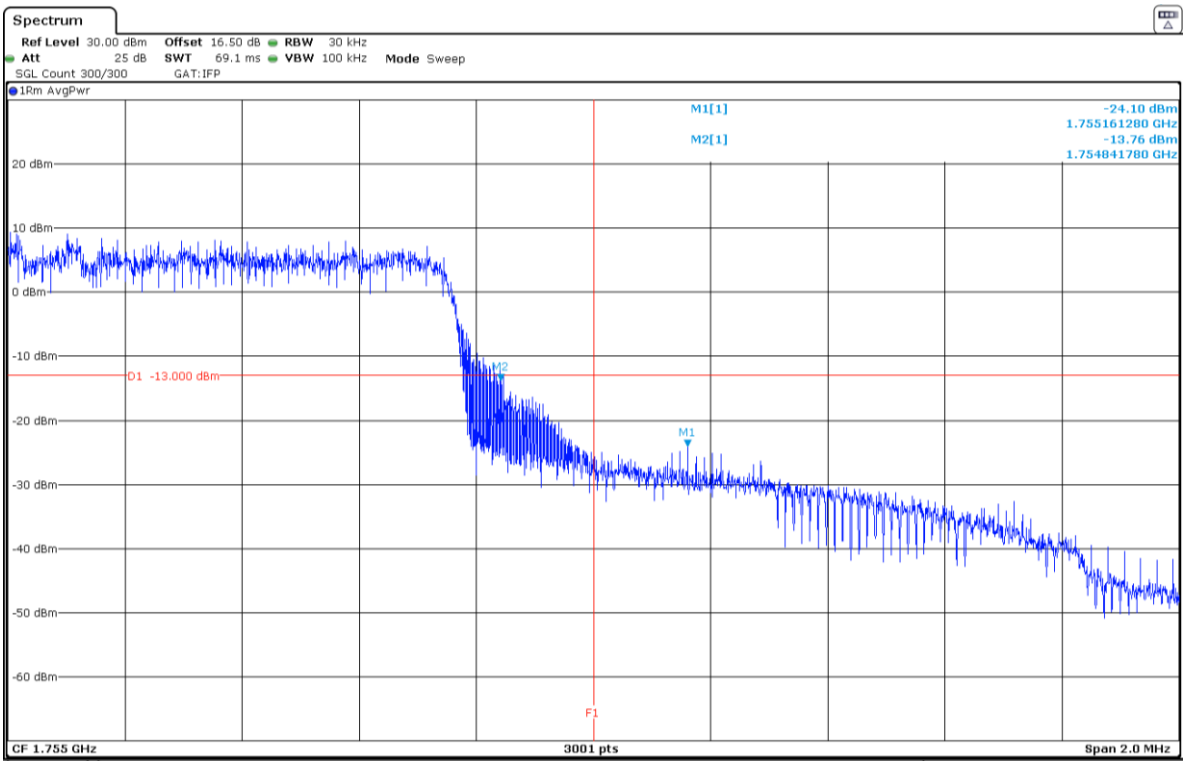
LTE Band 4:

NOTE: The equipment transmits at the maximum output power.

QPSK. Nominal Bandwidth 5 MHz. RB Size 1, RB Offset Max. Narrow band = 3. High Block Edge:



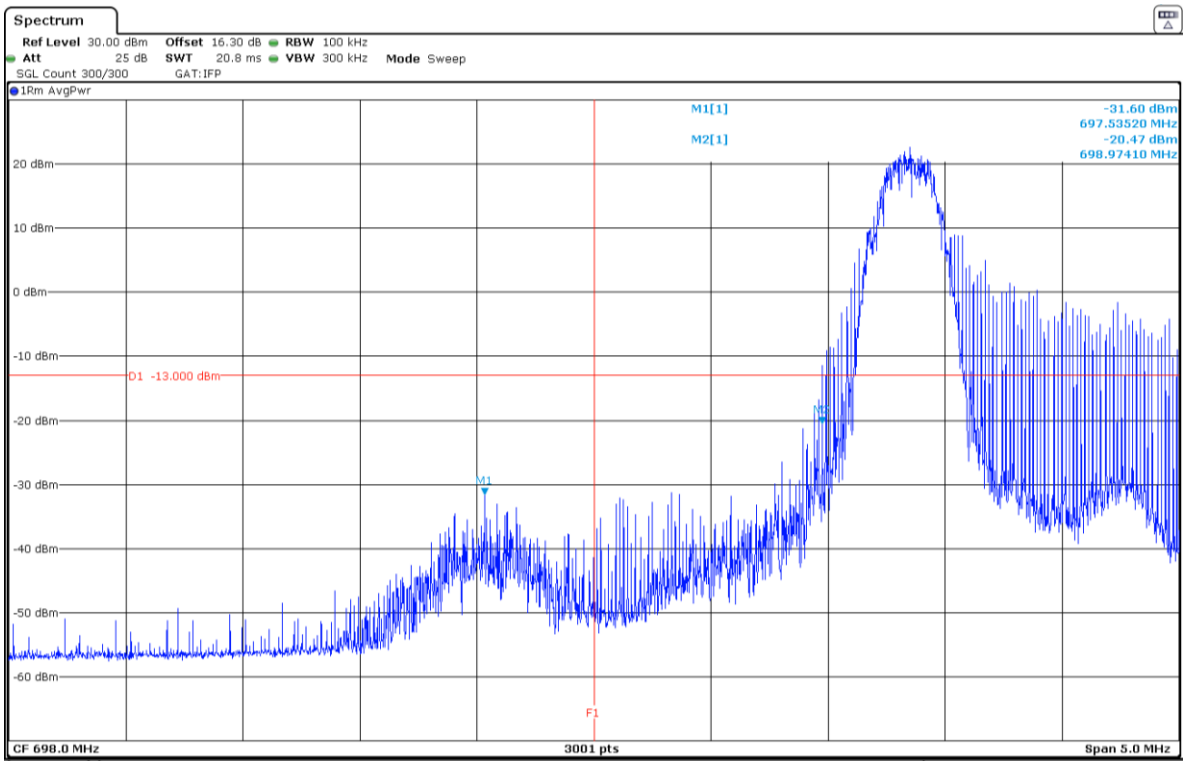
QPSK. Nominal Bandwidth 5 MHz. RB Size All, RB Offset 0. Narrow band = 3. High Block Edge:



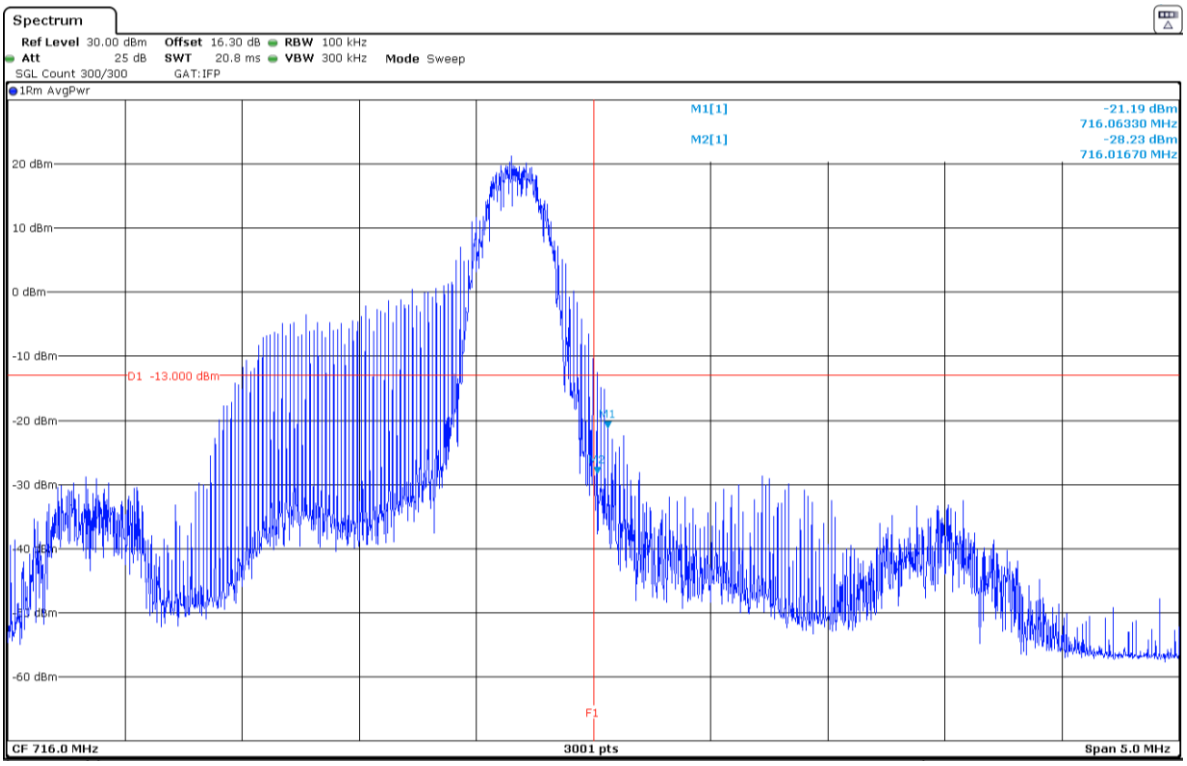
LTE Band 12:

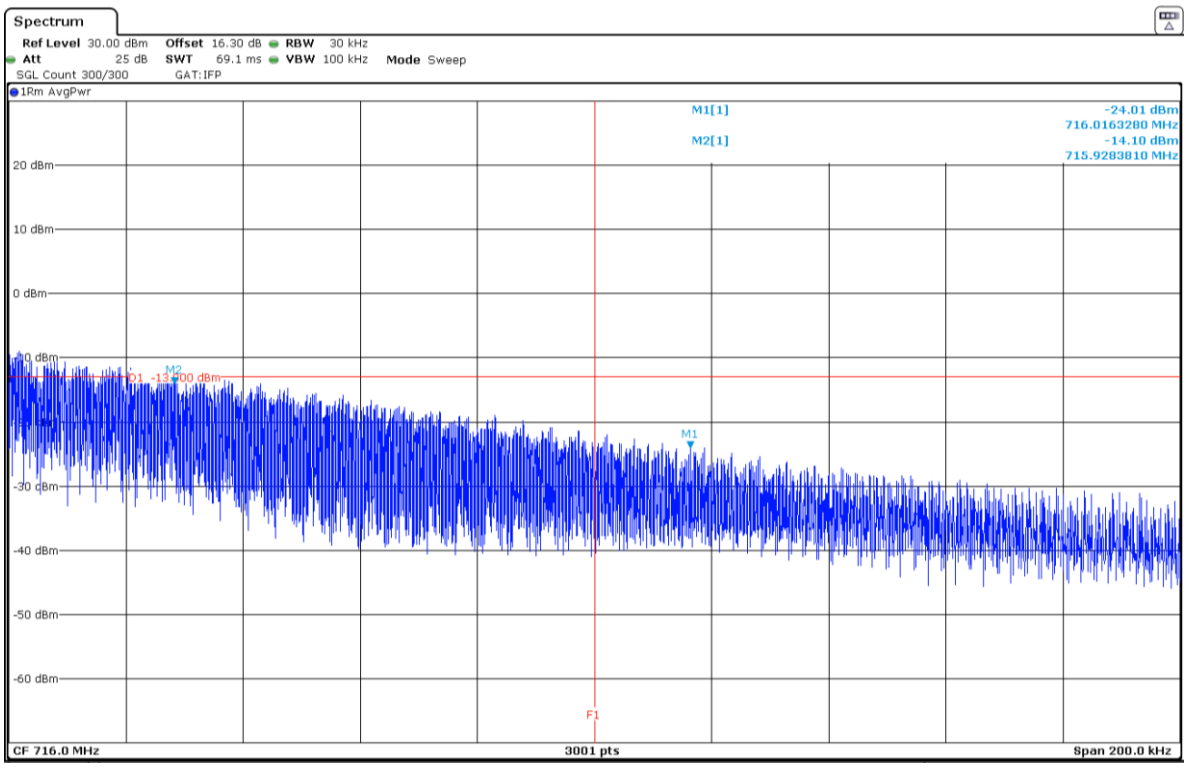
NOTE: The equipment transmits at the maximum output power.

QPSK. Nominal Bandwidth 5 MHz. RB Size 1, RB Offset 0. Narrow band = 0. Low Block Edge:



QPSK. Nominal Bandwidth 5 MHz. RB Size 1, RB Offset Max. Narrow band = 3. High Block Edge:





NOTE: Zoom (100kHz) with RBW=30kHz.

QPSK. Nominal Bandwidth 5 MHz. RB Size All, RB Offset 0. Narrow band = 0. Low Block Edge: