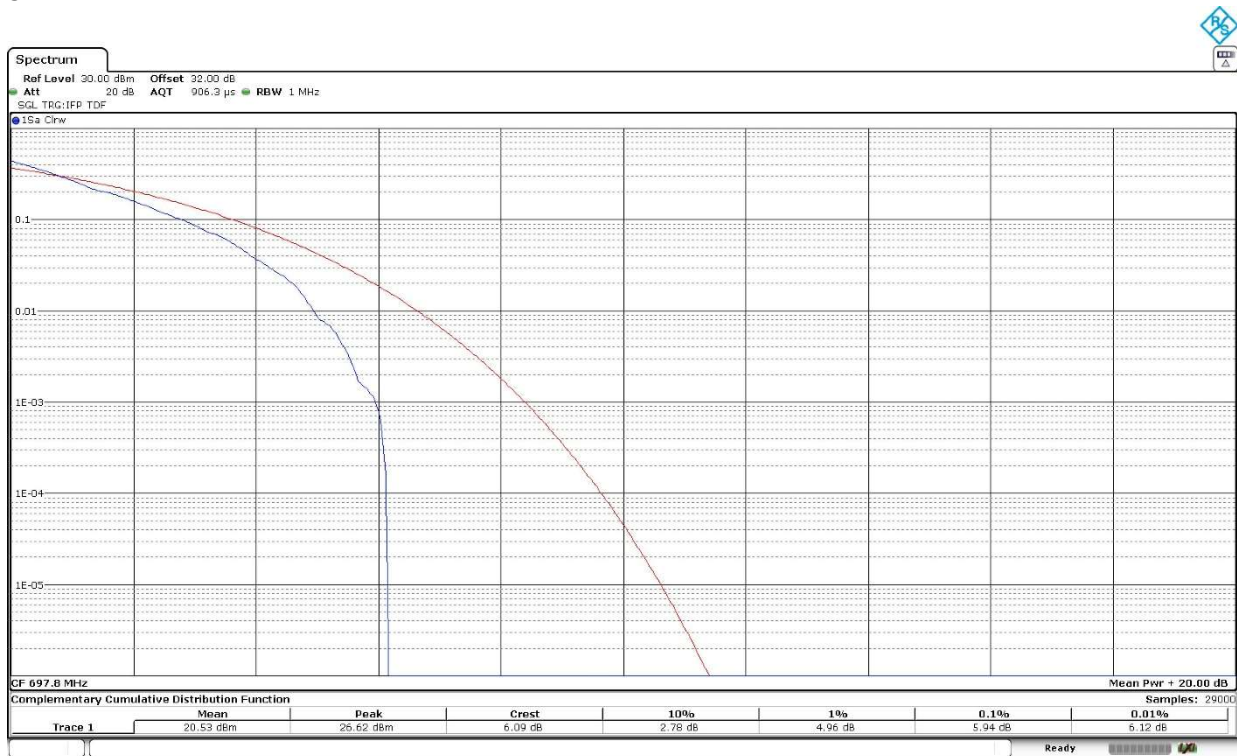


High Channel:



QPSK	Low	Middle	High
PAPR (dB)	6.09	8.35	5.94

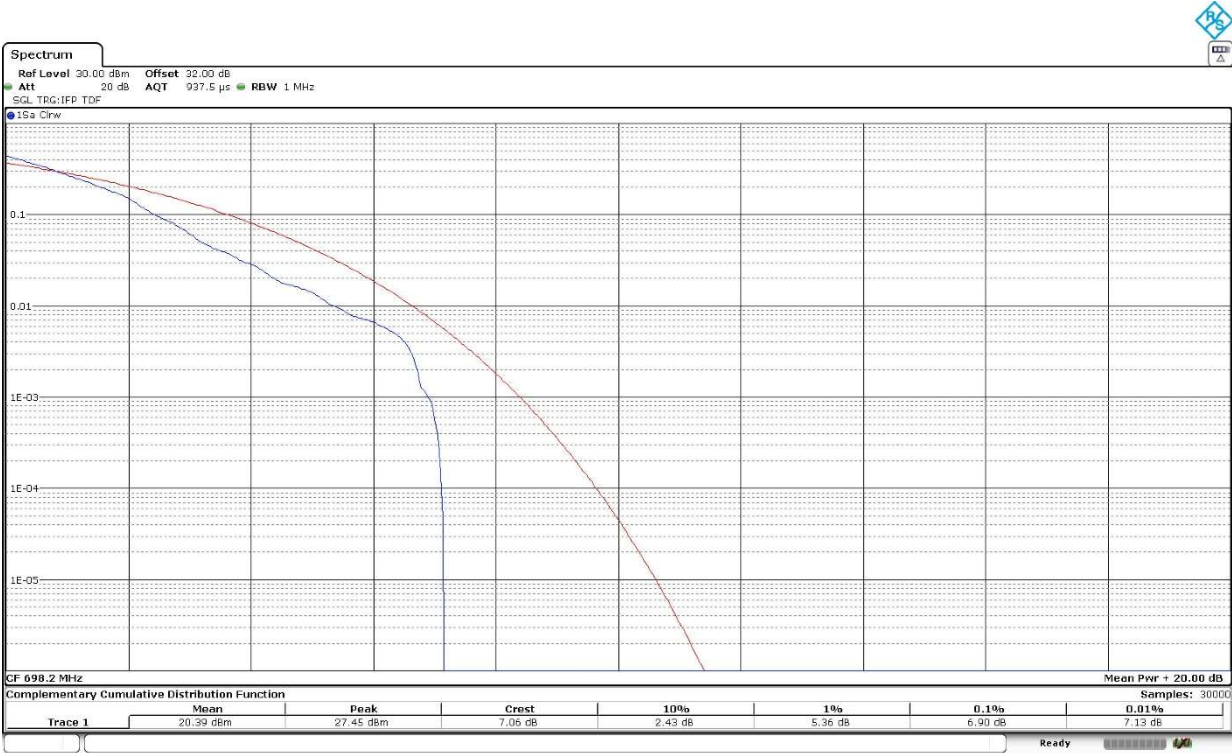
Verdict

Pass

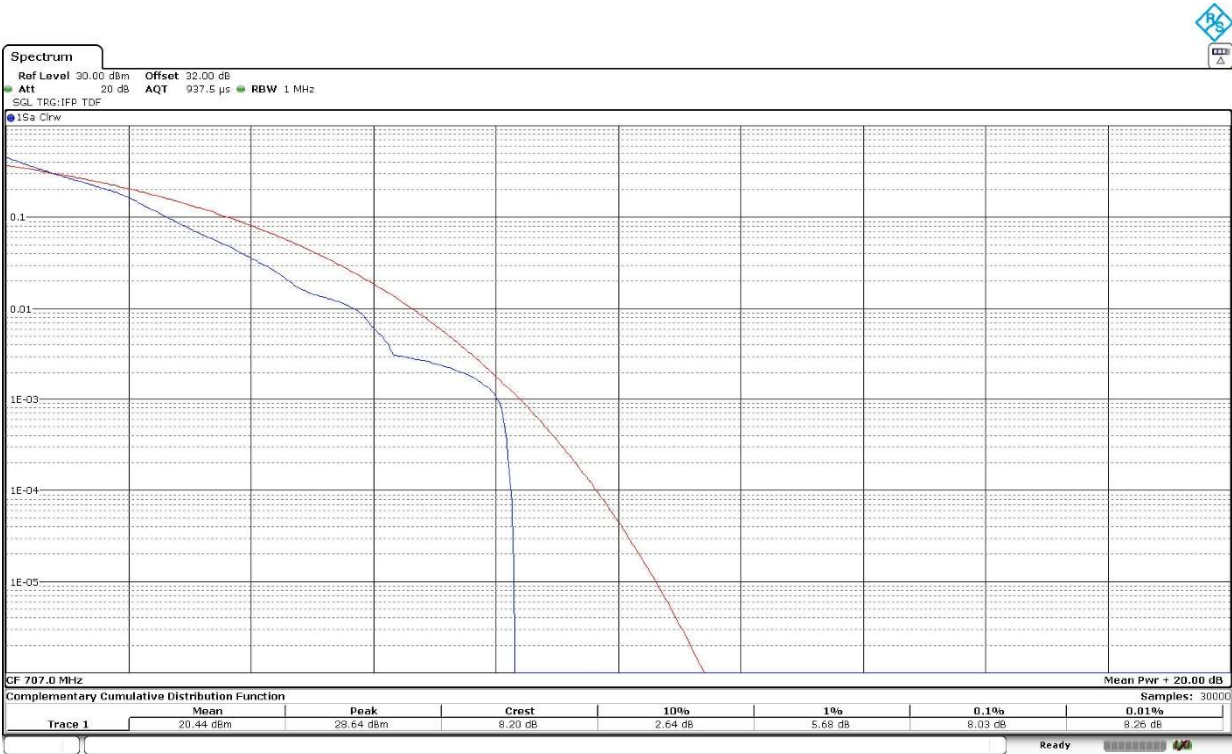
LTE Cat NB1 Band 85:

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

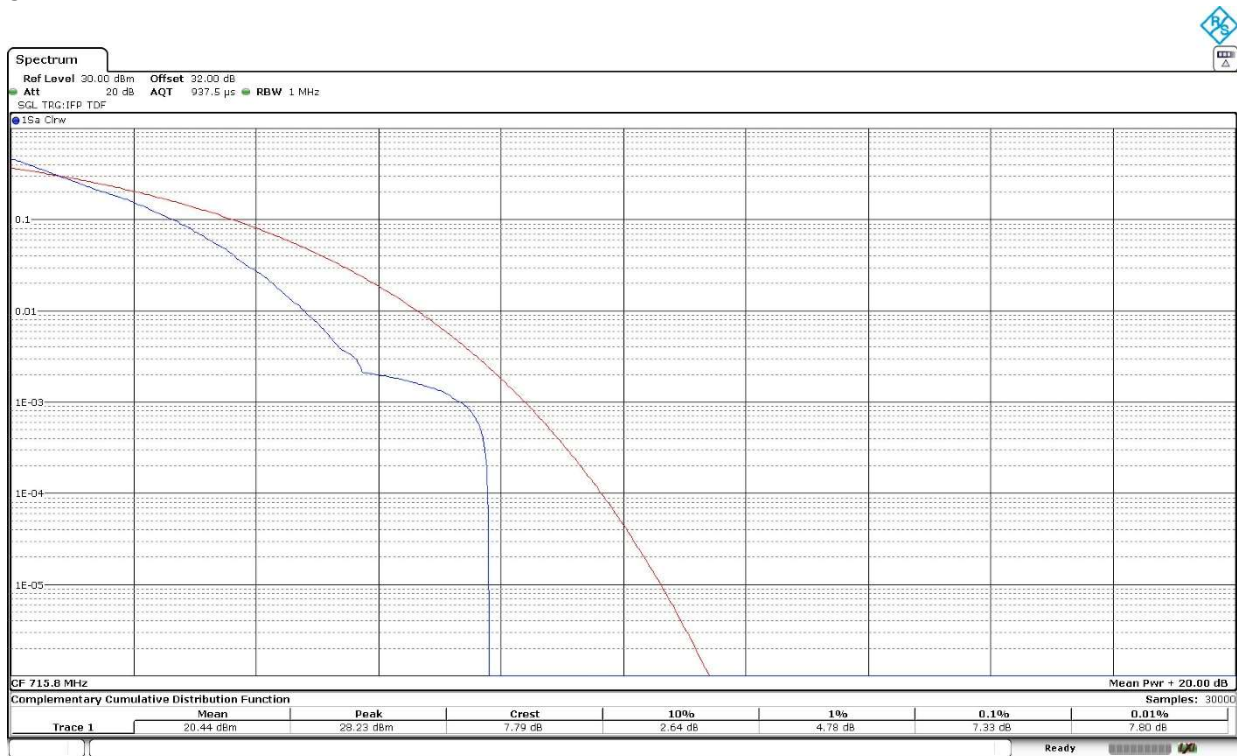
Low Channel:



Middle Channel:



High Channel:



QPSK	Low	Middle	High
PAPR (dB)	6.90	8.03	7.33

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

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

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

The EUT was set in "Radio Resource Control (RRC) mode" on the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.

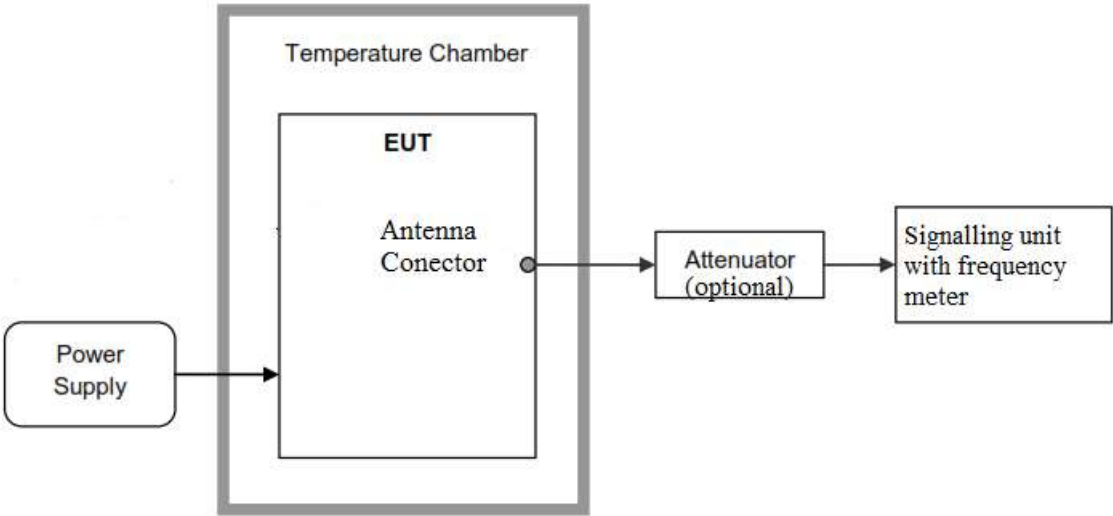
The worst case LTE mode for conducted power was used for the test.

In order to check that the frequency stability is sufficient such that the fundamental emissions stay within the authorized bands of operation, a reference point is established at the applicable unwanted emissions limit using a RBW equal to the RBW required by the unwanted emissions specification of the applicable regulatory standard. These reference points measured using the 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.

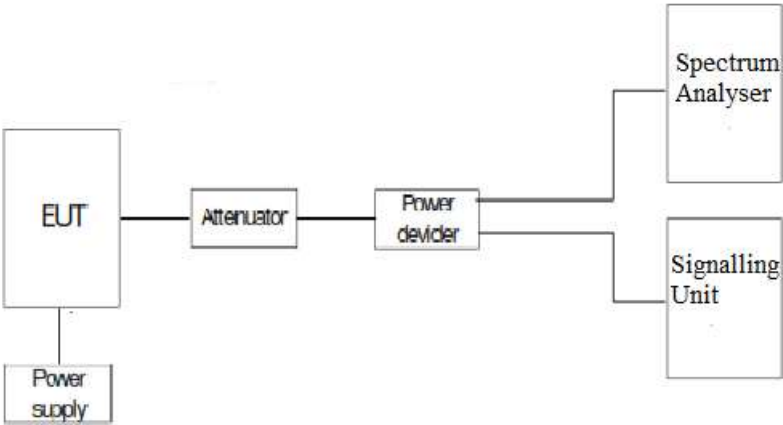
The reference point measurements were made at the RF output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

Test Setup

Frequency tolerance.



Reference points f_L and f_H .



Results

3. FREQUENCY TOLERANCE:

- Frequency stability over temperature variations:

LTE Cat NB1 Band 8:

The worst case modulation in terms of Frequency Stability is Pi/2-BPSK, BW=15 kHz, Tone Number=3, Tone Offset=0, MSC/TBS=0.

Temperature (°C)	Frequency Error (Hz)	Frequency Error (ppm)
+85	4,77	0,005312987
+80	3,52	0,003920695
+70	6,86	0,0076409
+60	5,47	0,006092671
+50	7,31	0,008142125
+40	6,21	0,006916908
+30	6,53	0,007273335
+20	3,33	0,003709067
+10	3,18	0,003541992
0	5,13	0,005713967
-10	2,63	0,002929383
-20	5,19	0,005780798
-30	2,32	0,002584094
-40	7,2	0,008019603

LTE Cat NB1 Band 13:

The worst case modulation in terms of Frequency Stability is QPSK, BW=15 kHz, Tone Number=3, Tone Offset=6, MSC/TBS=5.

Temperature (°C)	Frequency Error (Hz)	Frequency Error (ppm)
+85	-11,07	-0,01415601
+80	-8,76	-0,011202046
+70	-8,64	-0,011048593
+60	-5,42	-0,006930946
+50	-9,28	-0,011867008
+40	-7,31	-0,009347826
+30	-5,49	-0,00702046
+20	-8,77	-0,011214834
+10	-6,55	-0,008375959
0	3,18	0,004066496
-10	0,20	0,000255754
-20	3,68	0,004705882
-30	4,13	0,00528133
-40	-16,61	-0,021240409

LTE Cat NB1 Band 66:

The worst case modulation in terms of Frequency Stability is QPSK, BW=15 kHz, Tone Number=3, Tone Offset=6, MSC/TBS=5.

Temperature (°C)	Frequency Error (Hz)	Frequency Error (ppm)
+85	14,69	0,008418338
+80	-8,76	-0,005020057
+70	-8,64	-0,004951289

+60	-5,42	-0,003106017
+50	-4.56	-0.002613181
+40	-6.21	-0.003558739
+30	-5.42	-0.003106017
+20	-18.24	-0.010452722
+10	-2.96	-0.001696275
0	-4.41	-0.002527221
-10	14.63	0.008383954
-20	-1.66	-0.000951289
-30	-1.12	-0.000641834
-40	-2,55	-0,001461318

LTE Cat NB1 Band 71:

The worst case modulation in terms of Frequency Stability is QPSK, BW=15 kHz, Tone Number=3, Tone Offset=6, MSC/TBS=5.

Temperature (°C)	Frequency Error (Hz)	Frequency Error (ppm)
+85	-6,74	-0,009904482
+80	-8,76	-0,012872888
+70	-8,64	-0,012696547
+60	-5,42	-0,007964732
+50	5,51	0,008096988
+40	0,30	0,000440852
+30	-6,57	-0,009654666
+20	-7,87	-0,011565026
+10	-3,00	-0,004408523
0	-3,91	-0,005745775
-10	-2,46	-0,003614989
-20	0,86	0,001263777
-30	11,54	0,016958119
-40	-20,89	-0,030698016

LTE Cat NB1 Band 85:

The worst case modulation in terms of Frequency Stability is QPSK, BW=15 kHz, Tone Number=3, Tone Offset=6, MSC/TBS=5.

Temperature (°C)	Frequency Error (Hz)	Frequency Error (ppm)
+85	-2,8	-0,003960396
+80	-8,76	-0,012390382
+70	-8,64	-0,012220651
+60	-5,42	-0,007666195
+50	-8,96	-0,012673267
+40	0,56	0,000792079
+30	-6,94	-0,009816124
+20	-10,50	-0,014851485
+10	11,23	0,015884017
0	-5,84	-0,008260255
-10	16,75	0,023691655
-20	1,54	0,002178218
-30	12,25	0,017326733
-40	-19,43	-0,02748232

- **Frequency stability over voltage variations:**

LTE Cat NB1 Band 8:

The worst case modulation in terms of Frequency Stability is Pi/2-BPSK, BW=15 kHz, Tone Number=3, Tone Offset=0, MSC/TBS=5.

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	2.47	0.00275117
Vmin	3	-1,77	-0,001971486

LTE Cat NB1 Band 13:

The worst case modulation in terms of Frequency Stability is QPSK, BW=15 kHz, Tone Number=3, Tone Offset=6, MSC/TBS=5.

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	-7.44	-0.009514066
Vmin	3	-2,66	-0,003401535

LTE Cat NB1 Band 66:

The worst case modulation in terms of Frequency Stability is QPSK, BW=15 kHz, Tone Number=3, Tone Offset=6, MSC/TBS=5.

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	-5.46	-0.00312894
Vmin	3	4,98	0,002853868

LTE Cat NB1 Band 71:

The worst case modulation in terms of Frequency Stability is QPSK, BW=15 kHz, Tone Number=3, Tone Offset=6, MSC/TBS=5.

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	-8.50	-0.012490816
Vmin	3	5,7	0,008376194

LTE Cat NB1 Band 85:

The worst case modulation in terms of Frequency Stability is QPSK, BW=15 kHz, Tone Number=3, Tone Offset=6, MSC/TBS=5.

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	-2.10	-0.002970297
Vmin	3	-6,33	-0,008953324

4. REFERENCE FREQUENCY POINTS f_L AND f_H :

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

LTE Cat NB1 Band 8:

The worst case modulation in terms of Frequency Stability is Pi/2-BPSK, BW=15 kHz, Tone Number=3, Tone Offset=0, MSC/TBS=5.

f_L (MHz)	897.5113
f_H (MHz)	900.4928

LTE Cat NB1 Band 13:

The worst case modulation in terms of Frequency Stability is QPSK, BW=15 kHz, Tone Number=3, Tone Offset=6, MSC/TBS=5.

f_L (MHz)	776.9937
f_H (MHz)	786.9688

LTE Cat NB1 Band 66:

The worst case modulation in terms of Frequency Stability is QPSK, BW=15 kHz, Tone Number=3, Tone Offset=6, MSC/TBS=5.

f_L (MHz)	1710.0556
f_H (MHz)	1779.9498

LTE Cat NB1 Band 71:

The worst case modulation in terms of Frequency Stability is QPSK, BW=15 kHz, Tone Number=3, Tone Offset=6, MSC/TBS=5.

f_L (MHz)	662.9790
f_H (MHz)	697.9921

LTE Cat NB1 Band 85:

The worst case modulation in terms of Frequency Stability is QPSK, BW=15 kHz, Tone Number=3, Tone Offset=6, MSC/TBS=5.

f_L (MHz)	698.0353
f_H (MHz)	715.9648

The reference frequency points f_L and f_H stay within the authorized blocks for the band above.

Measurement uncertainty (Hz): $<\pm 211.77$

Verdict

PASS

Modulation Characteristics

Limits

FCC §2.1047.

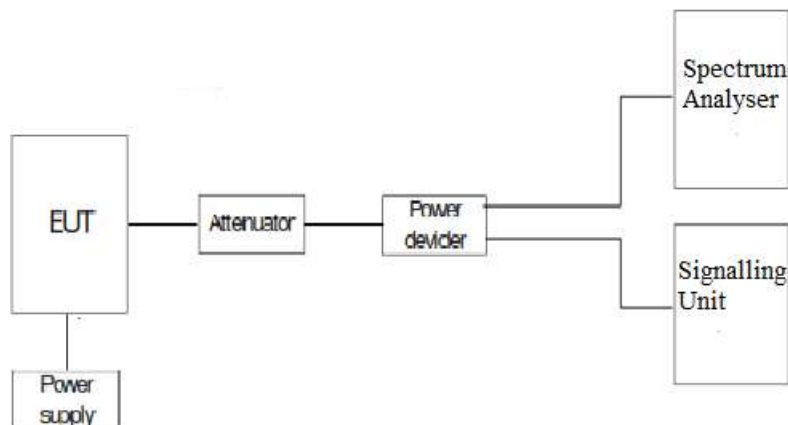
RSS-130, Clause 4.2: Equipment certified under this standard shall employ digital modulation.

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 NB1 the EUT operates with $\pi/2$ -BPSK, $\pi/4$ -QPSK and QPSK modulations in which the information is digitized and coded into a bit stream. The RF transmission is multiplexed using *Orthogonal Frequency Division Multiplexing (OFDM)* using different possible arrangement of subcarriers (Resource Blocks RB).

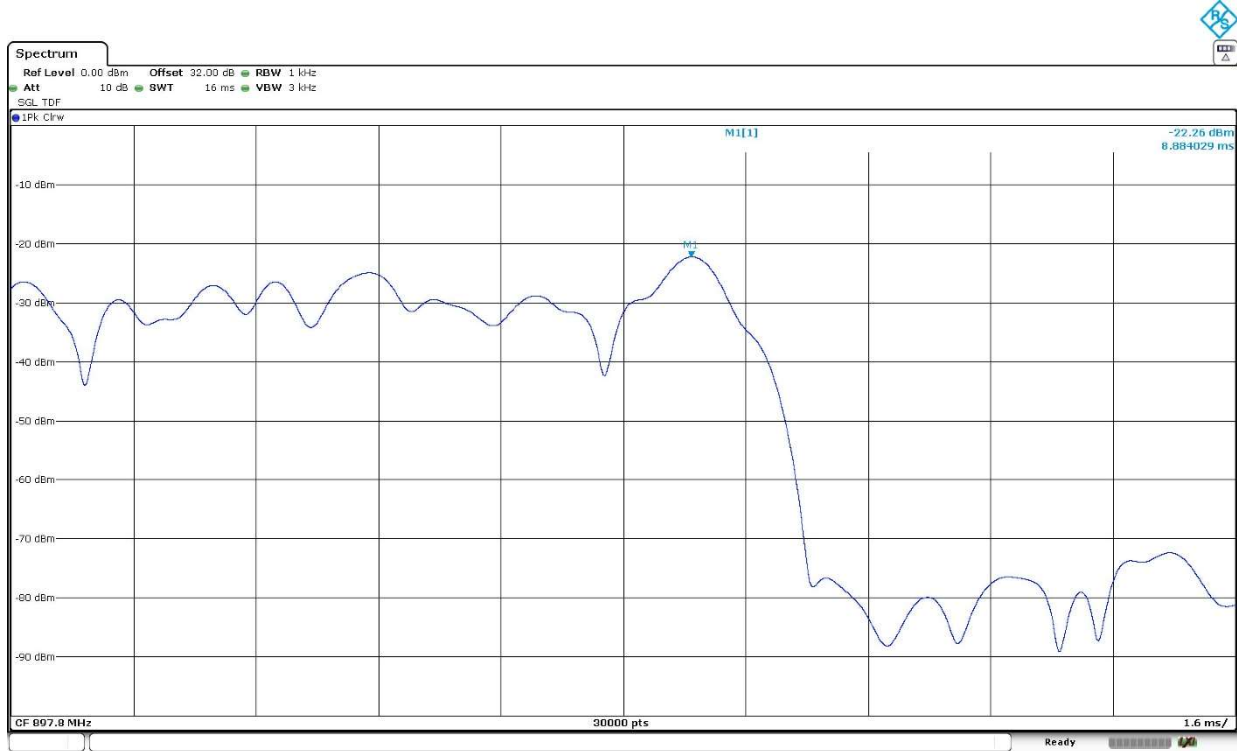
Test Setup



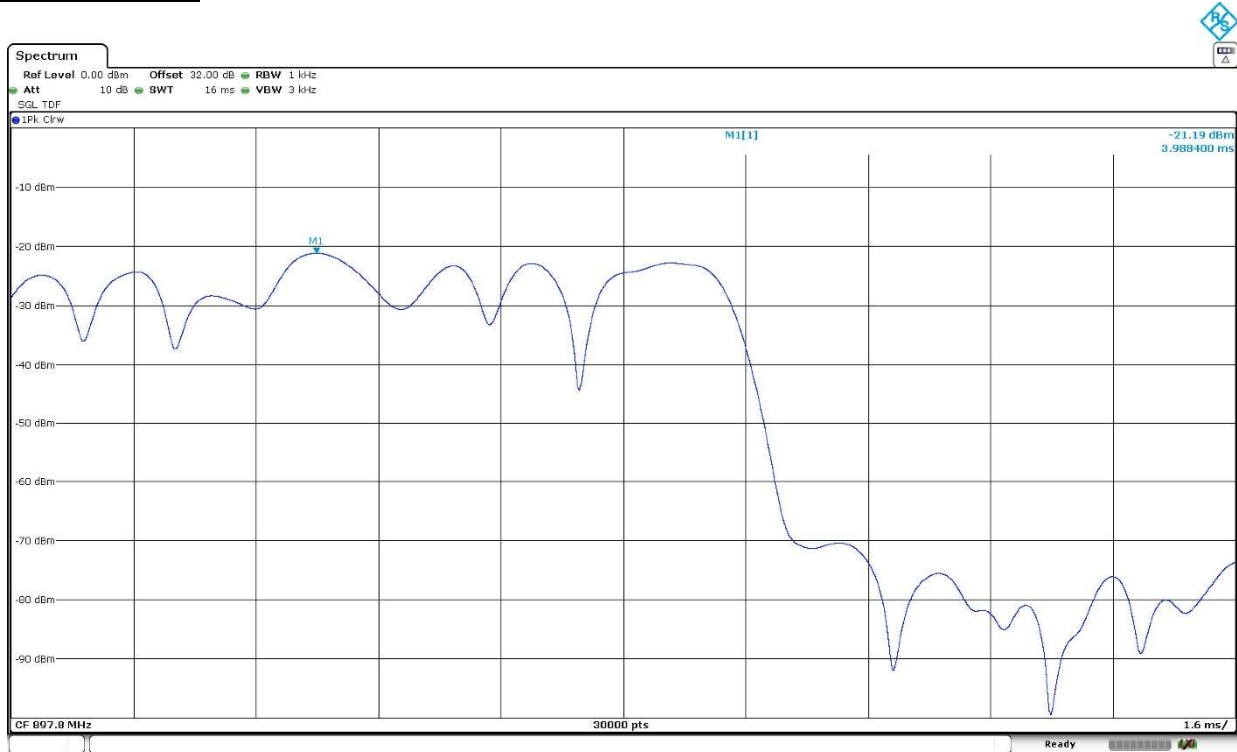
Results

The following plot shows the modulation schemes in the EUT.

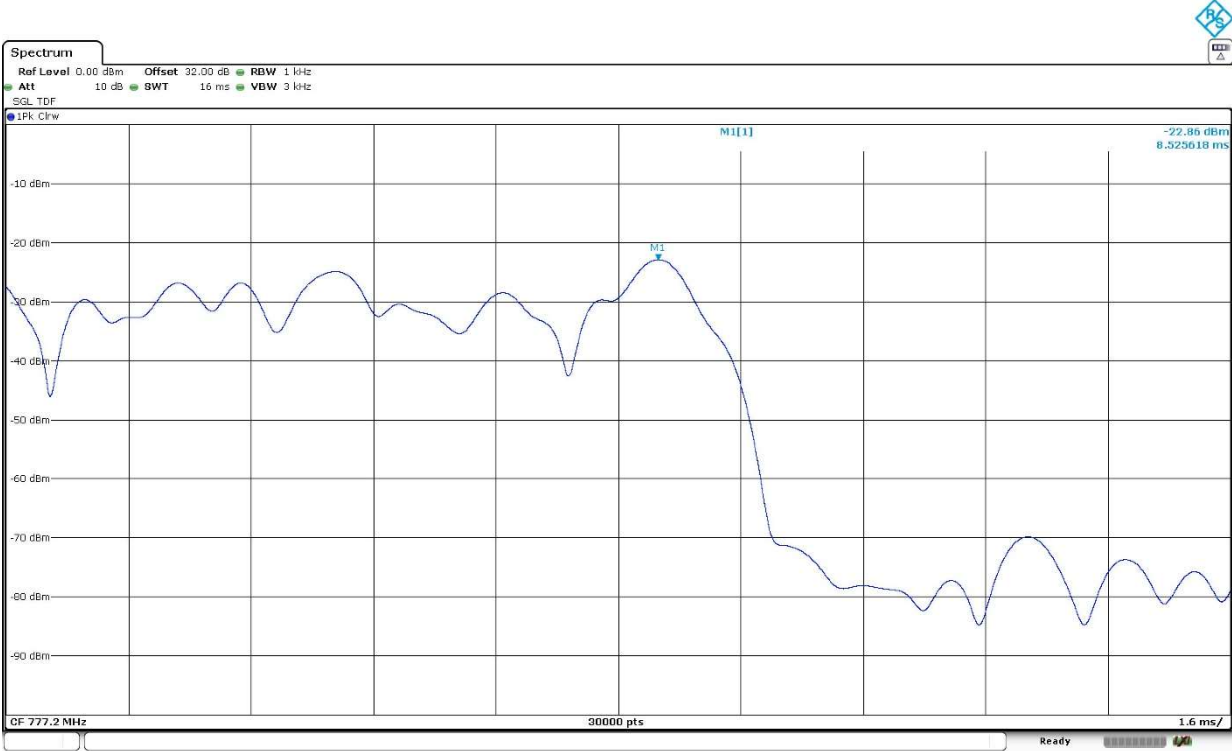
LTE Cat NB1 Band 8: Pi/2-BPSK. Low Channel. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=0.



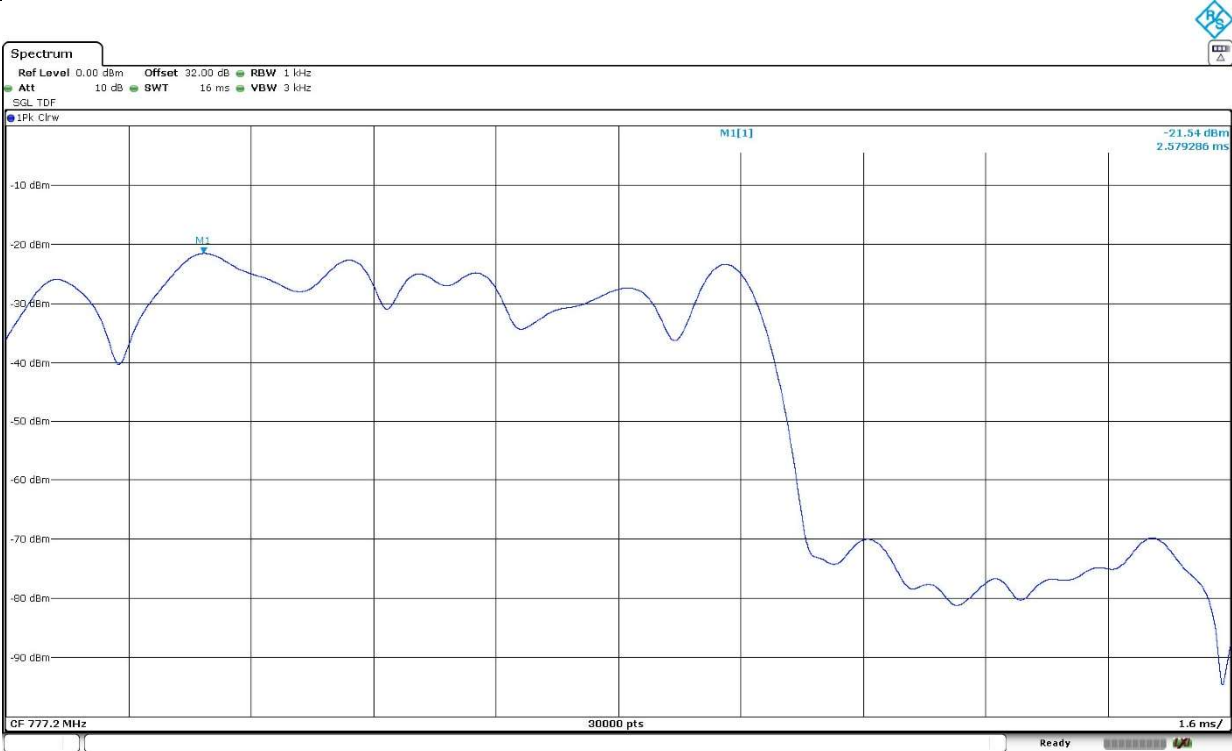
LTE Cat NB1 Band 8: Pi/4-QPSK. Low Channel. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=3.



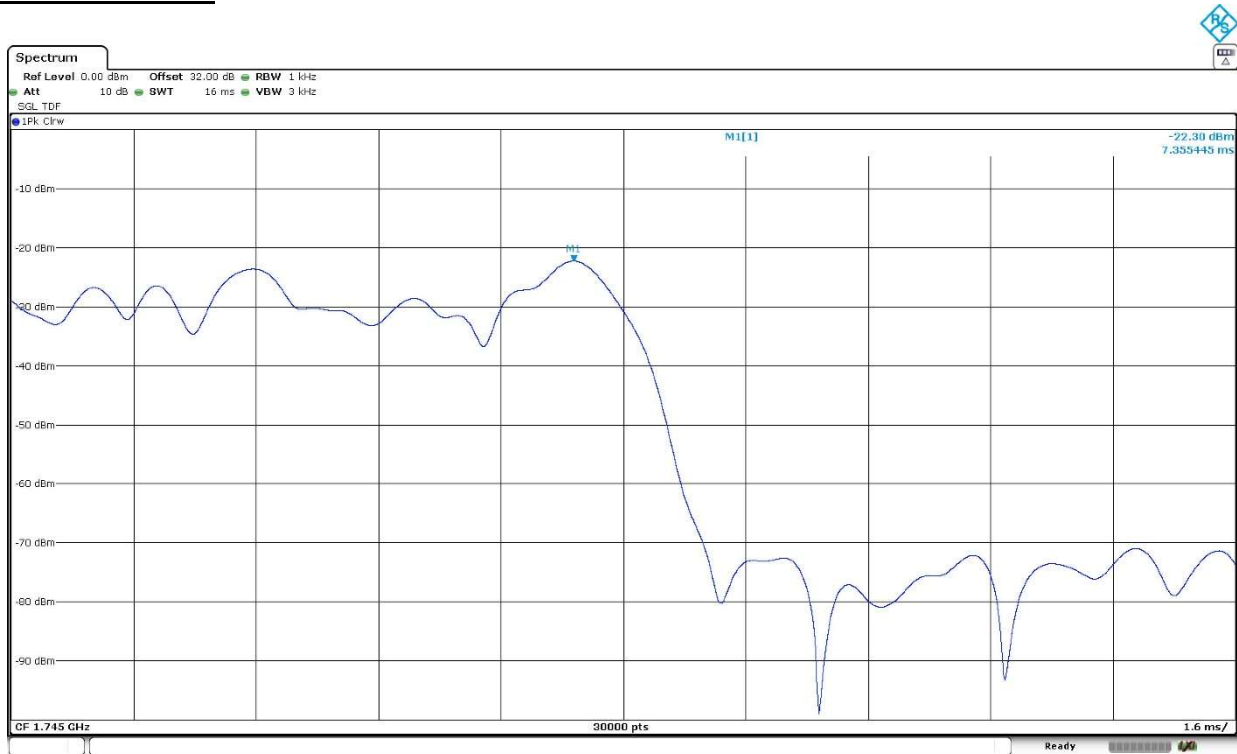
LTE Cat NB1 Band 13: Pi/2-BPSK. Low Channel. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=0.



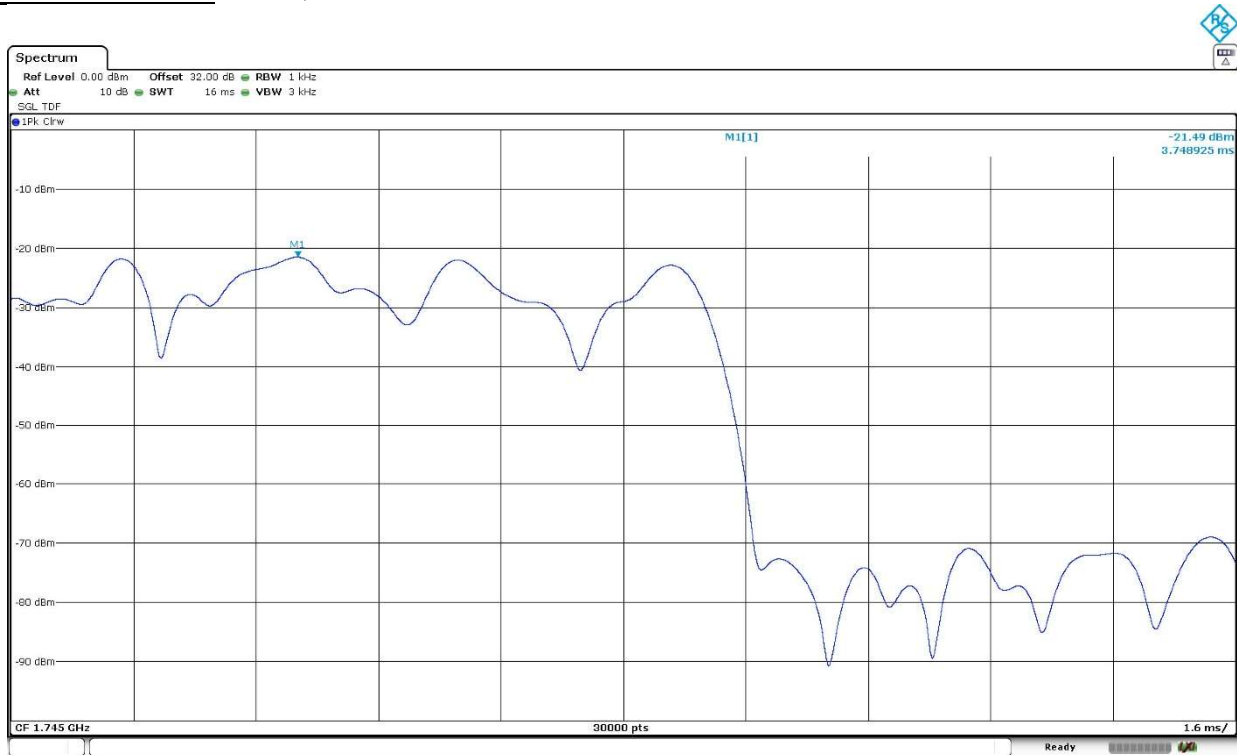
LTE Cat NB1 Band 13: Pi/4-QPSK. Low Channel. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=3.



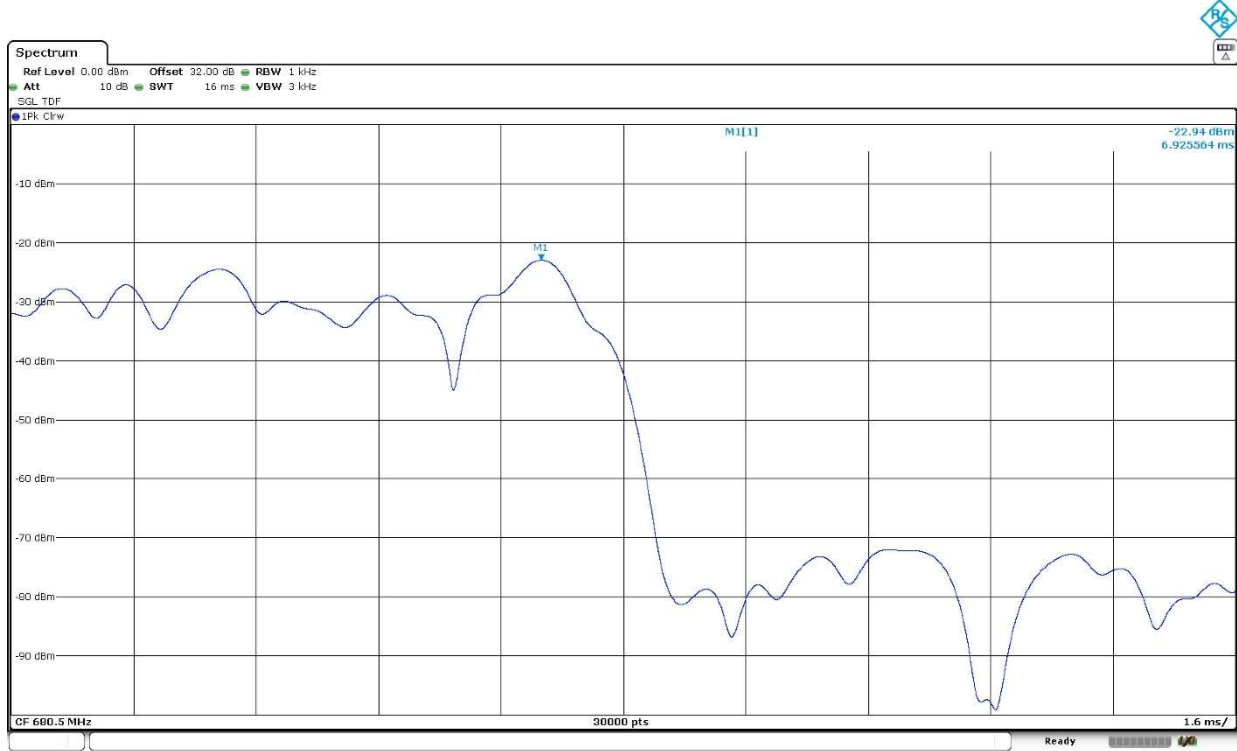
LTE Cat NB1 Band 66: Pi/2-BPSK. Middle Channel. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=0.



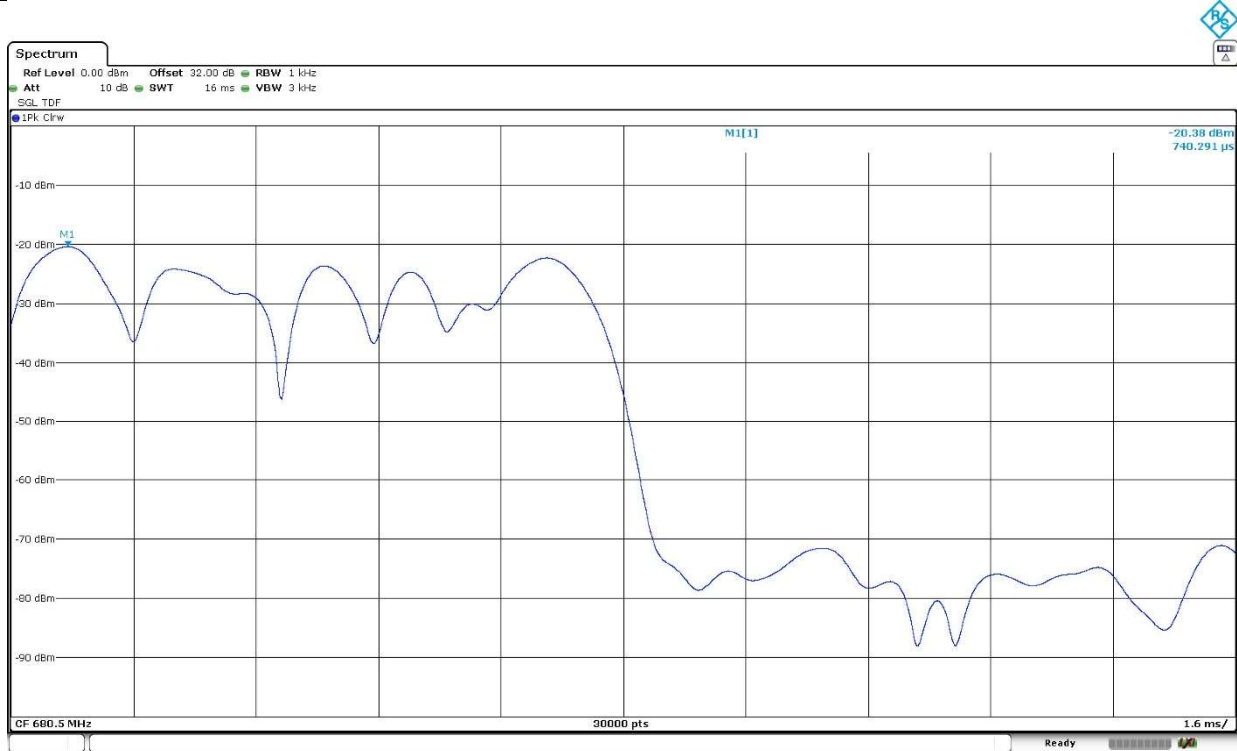
LTE Cat NB1 Band 66: Pi/4-QPSK. Middle Channel. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=3.



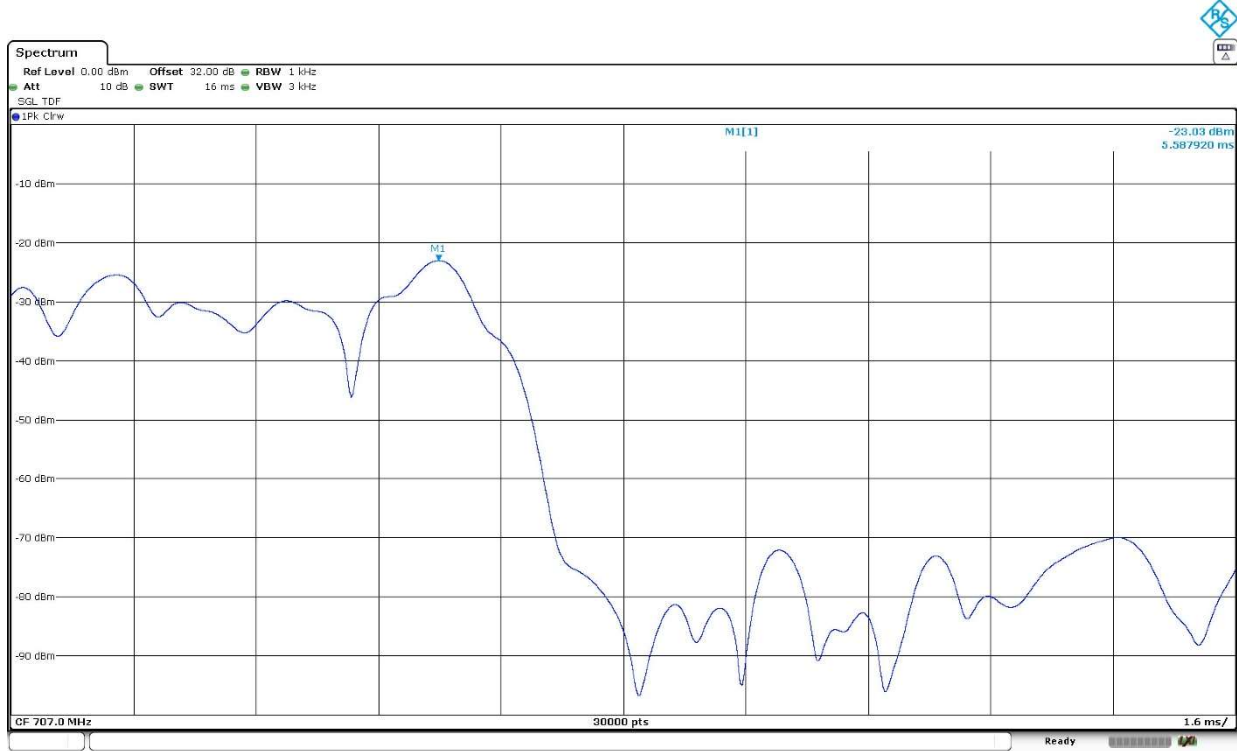
LTE Cat NB1 Band 71: Pi/2-BPSK. Middle Channel. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=0.



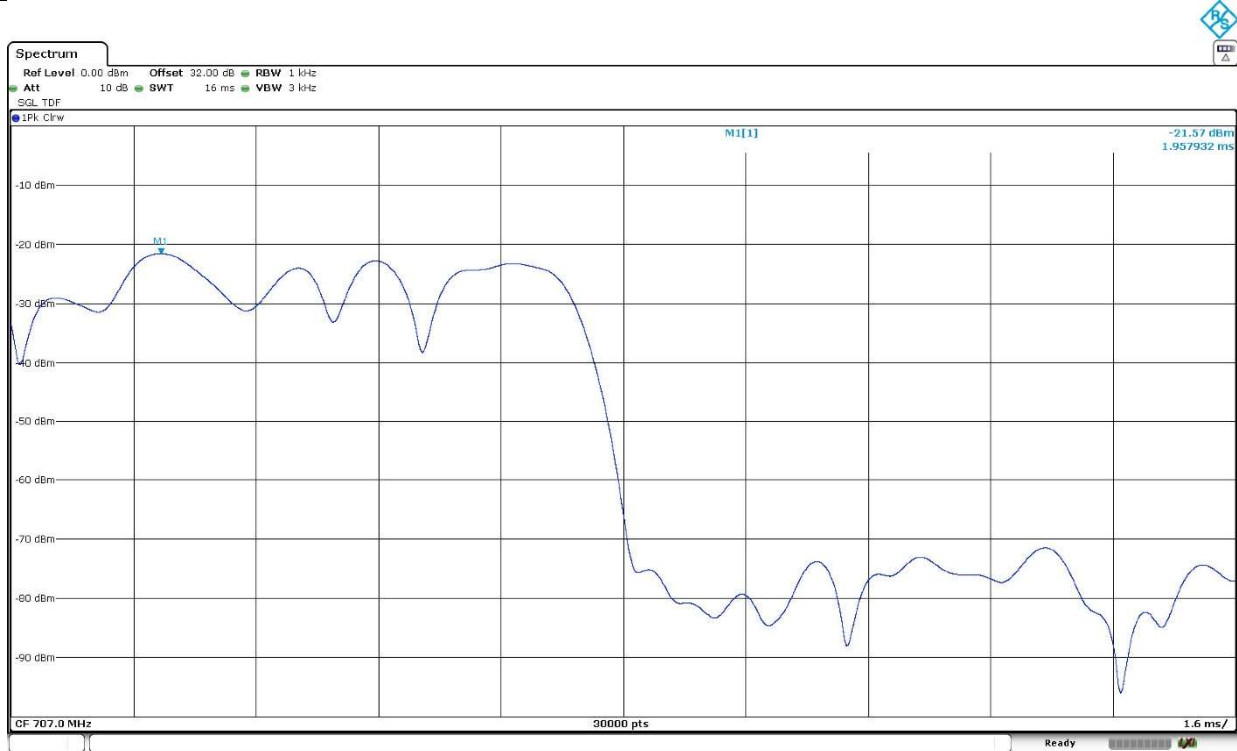
LTE Cat NB1 Band 71: Pi/4-QPSK. Middle Channel. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=3.



LTE Cat NB1 Band 85: Pi/2-BPSK. Middle Channel. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=0.



LTE Cat NB1 Band 85: Pi/4-QPSK. Middle Channel. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=3.



Occupied Bandwidth

Limits

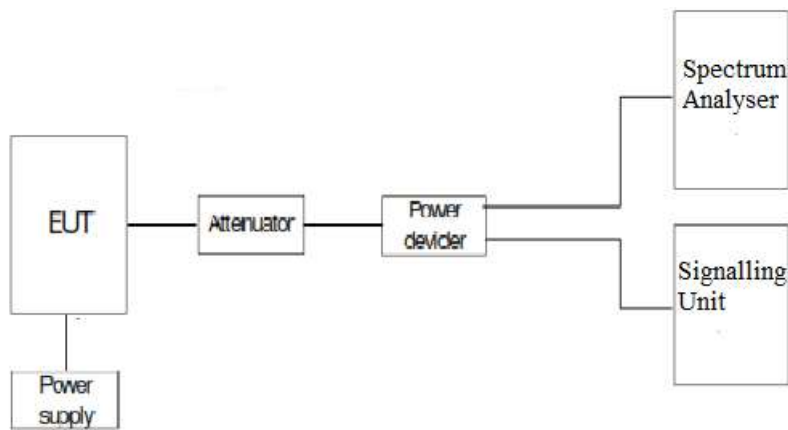
FCC §2.1049. Measurements required: Occupied bandwidth.

RSS-Gen, Clause 6.7.

Method

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

Test Setup



Results

The worst case of occupied bandwidth corresponds to the following ones.

LTE Cat NB1 Band 8:

LTE Cat NB1 Band 8. Pi/2-BPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=23. MSC/TBS=0.

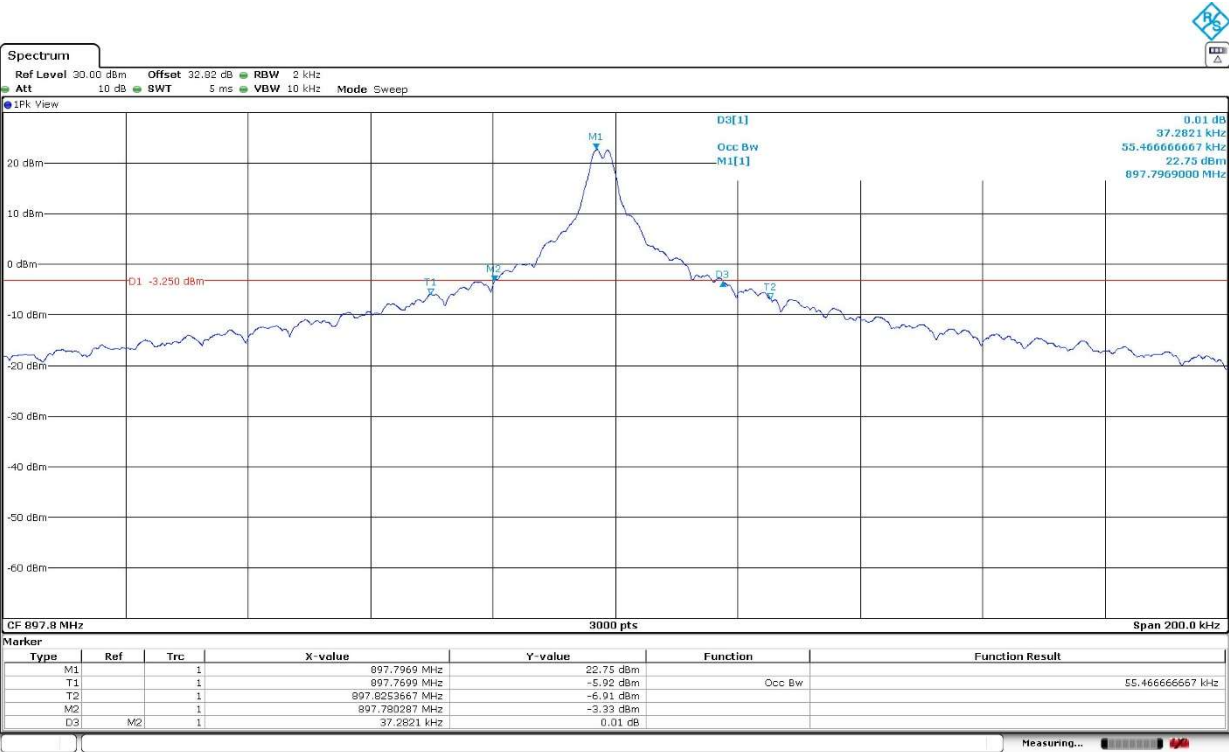
	Low Channel	High Channel
99% Occupied Bandwidth (kHz)	55.467	58.800
-26 dBc Bandwidth (kHz)	37.282	40.074
Measurement uncertainty (kHz)	<±0.35	

LTE Cat NB1 Band 8. Pi/4-QPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=23. MSC/TBS=3.

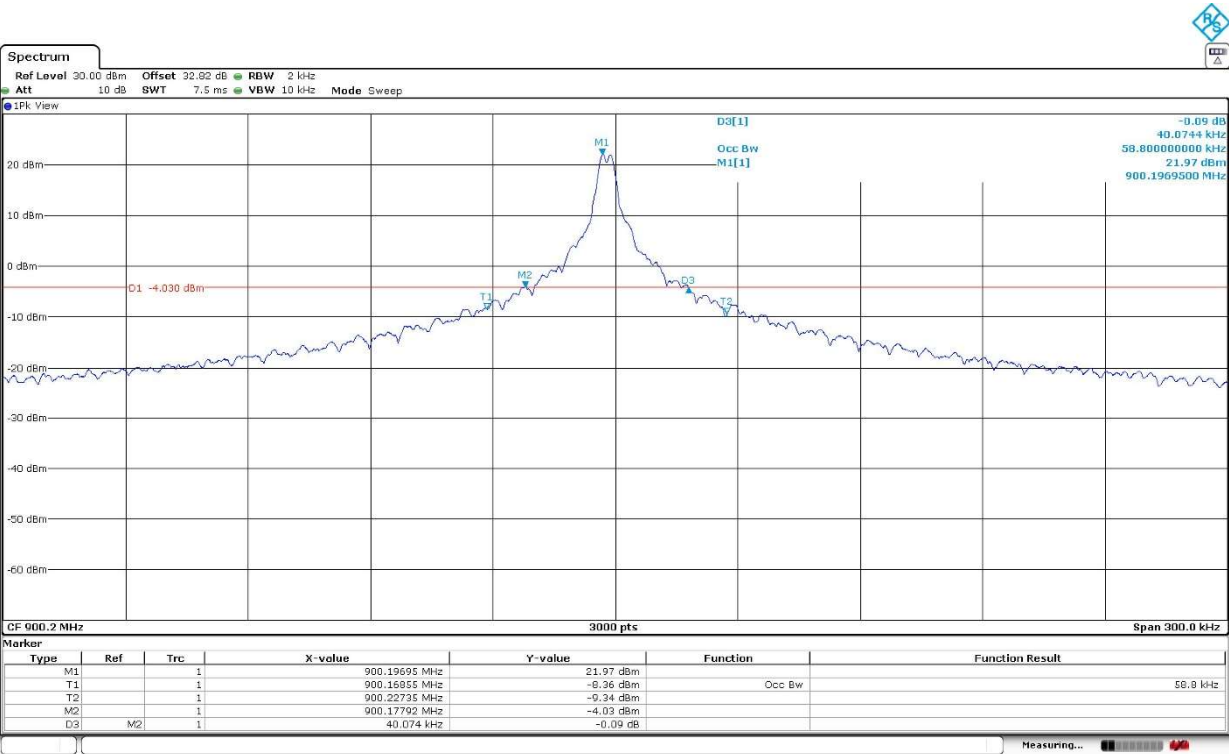
	Low Channel	High Channel
99% Occupied Bandwidth (kHz)	60.600	63.000
-26 dBc Bandwidth (kHz)	41.682	42.074
Measurement uncertainty (kHz)	<±0.35	

LTE Cat NB1 Band 8. Pi/2-BPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=23. MSC/TBS=0.

Low Channel:

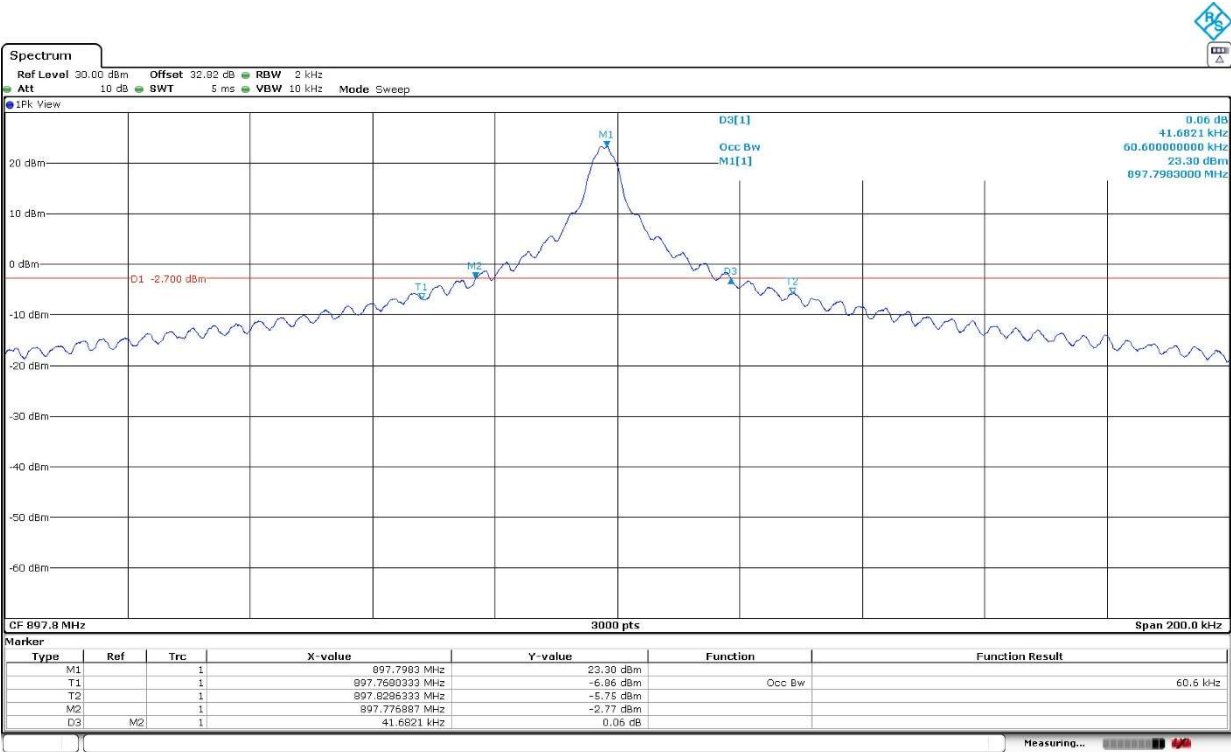


High Channel:

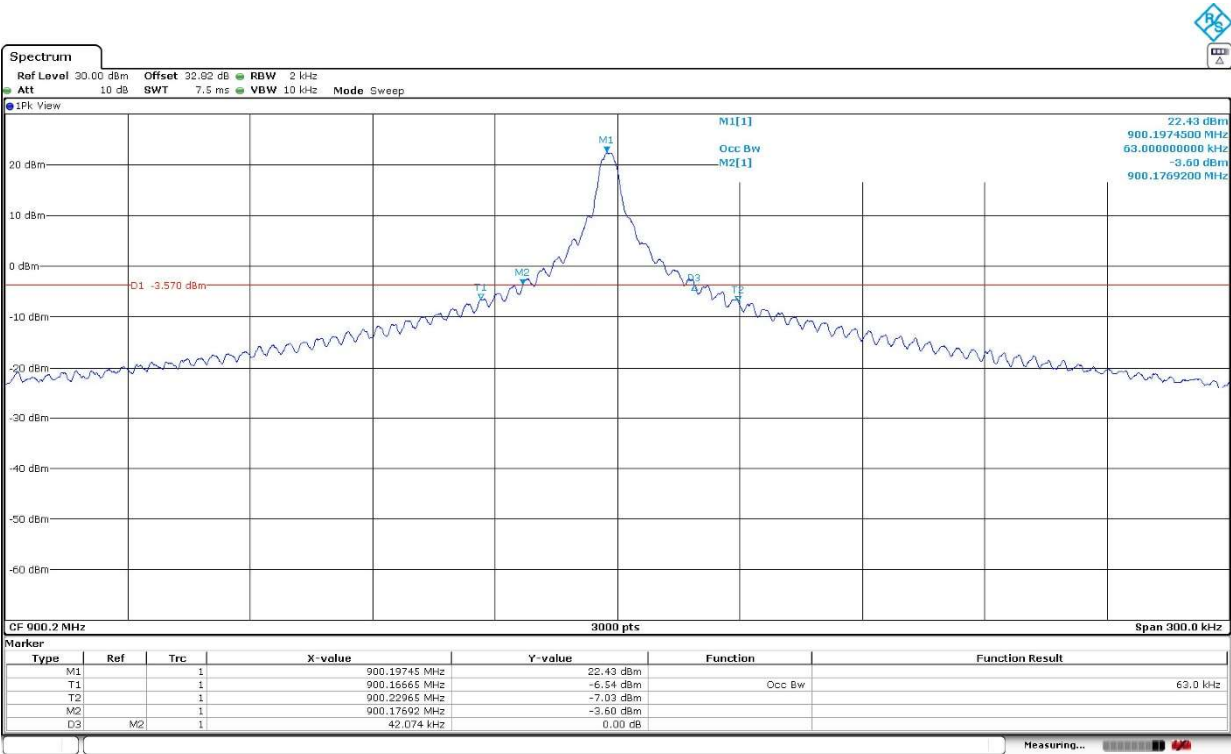


LTE Cat NB1 Band 8. Pi/4-QPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=23. MSC/TBS=3.

Low Channel:



High Channel:



LTE Cat NB1 Band 8. Pi/2-BPSK. BW=15 kHz. Tone Number=1. Tone Offset=5. MSC/TBS=0.

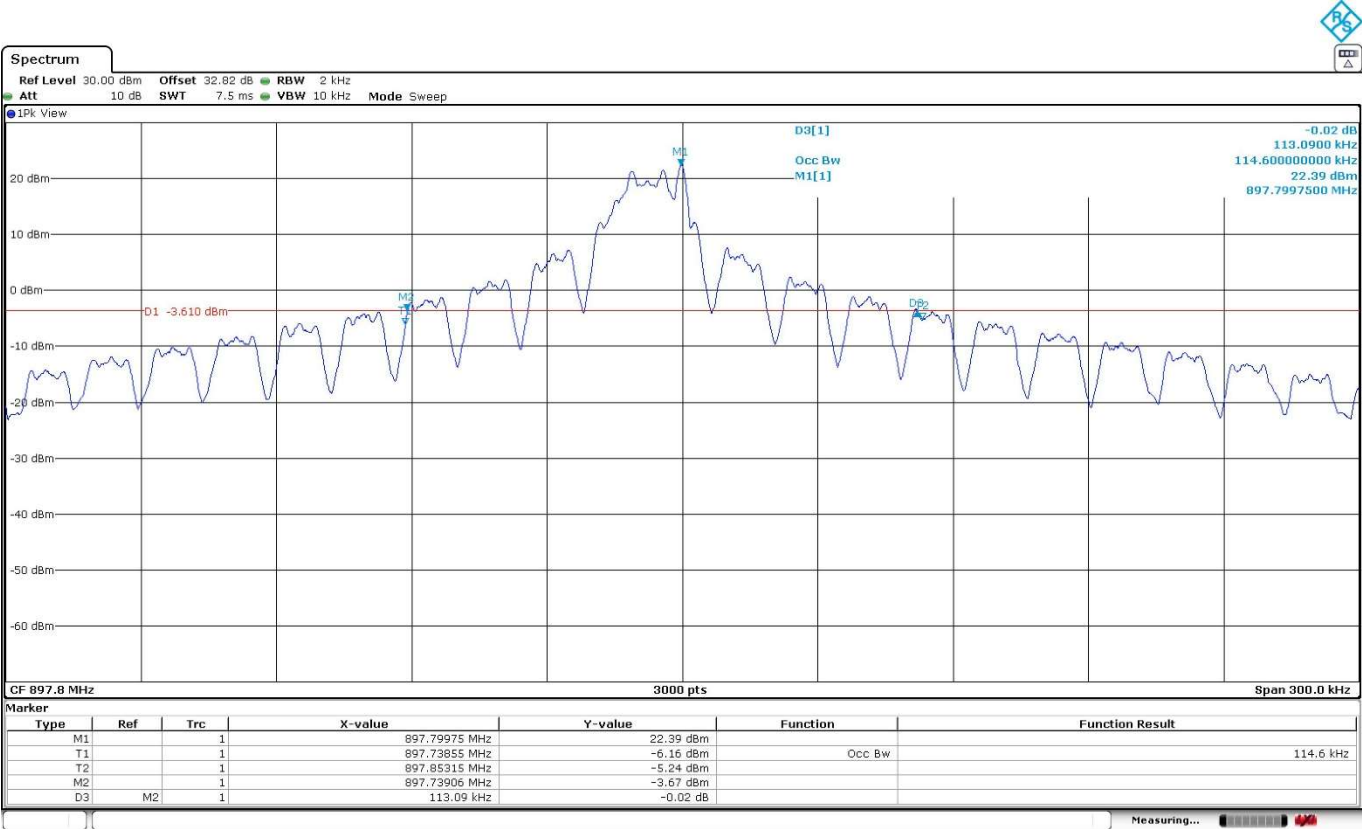
	Low Channel	High Channel
99% Occupied Bandwidth (kHz)	114.600	125.400
-26 dBc Bandwidth (kHz)	113.090	127.796
Measurement uncertainty (kHz)	<±0.58	

LTE Cat NB1 Band 8. QPSK. BW=15 kHz. Tone Number=12. Tone Offset=0. MSC/TBS=5.

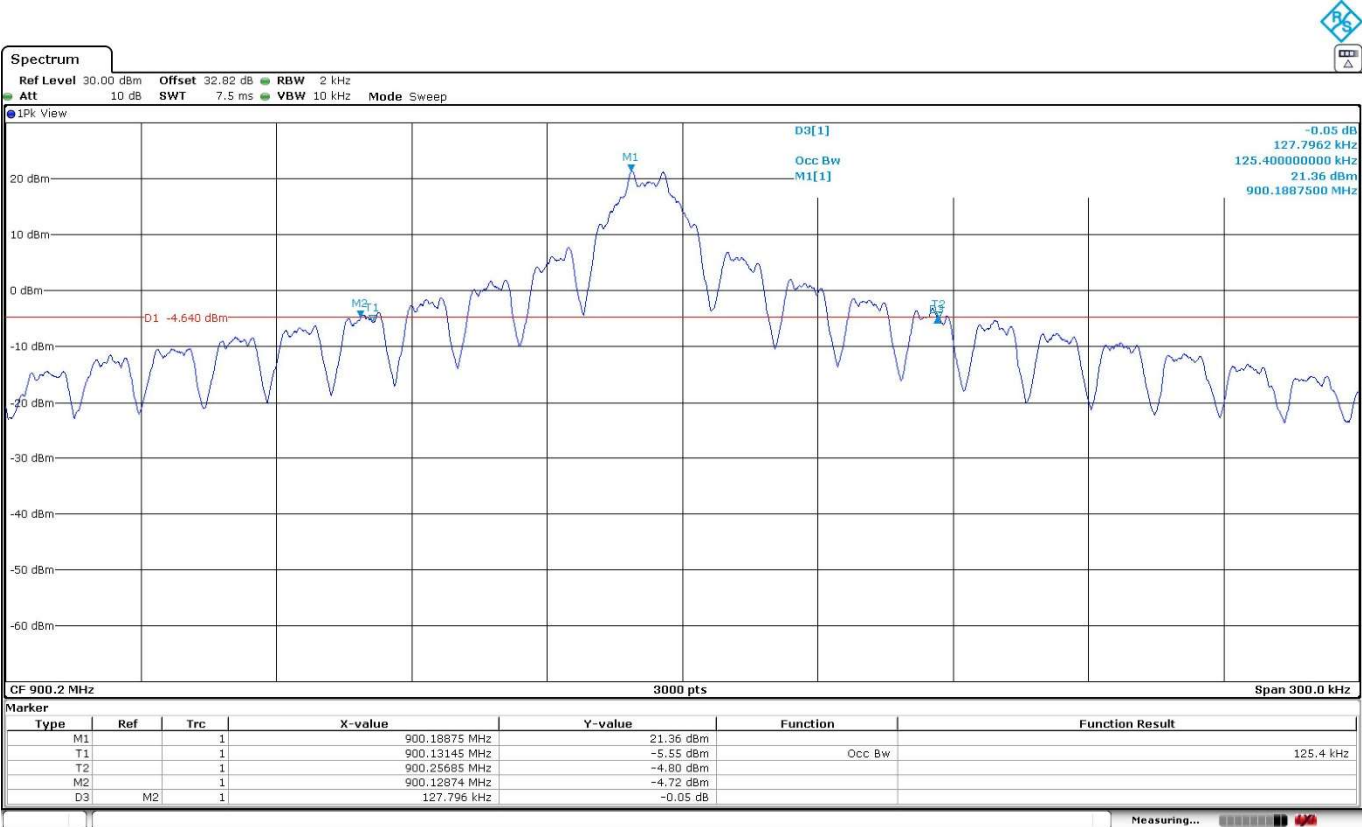
	Low Channel	High Channel
99% Occupied Bandwidth (kHz)	185.333	185.333
-26 dBc Bandwidth (kHz)	284.320	287.720
Measurement uncertainty (kHz)	<±0.58	

LTE Cat NB1 Band 8. Pi/2-BPSK. BW=15 kHz. Tone Number=1. Tone Offset=5. MSC/TBS=0.

Low Channel:

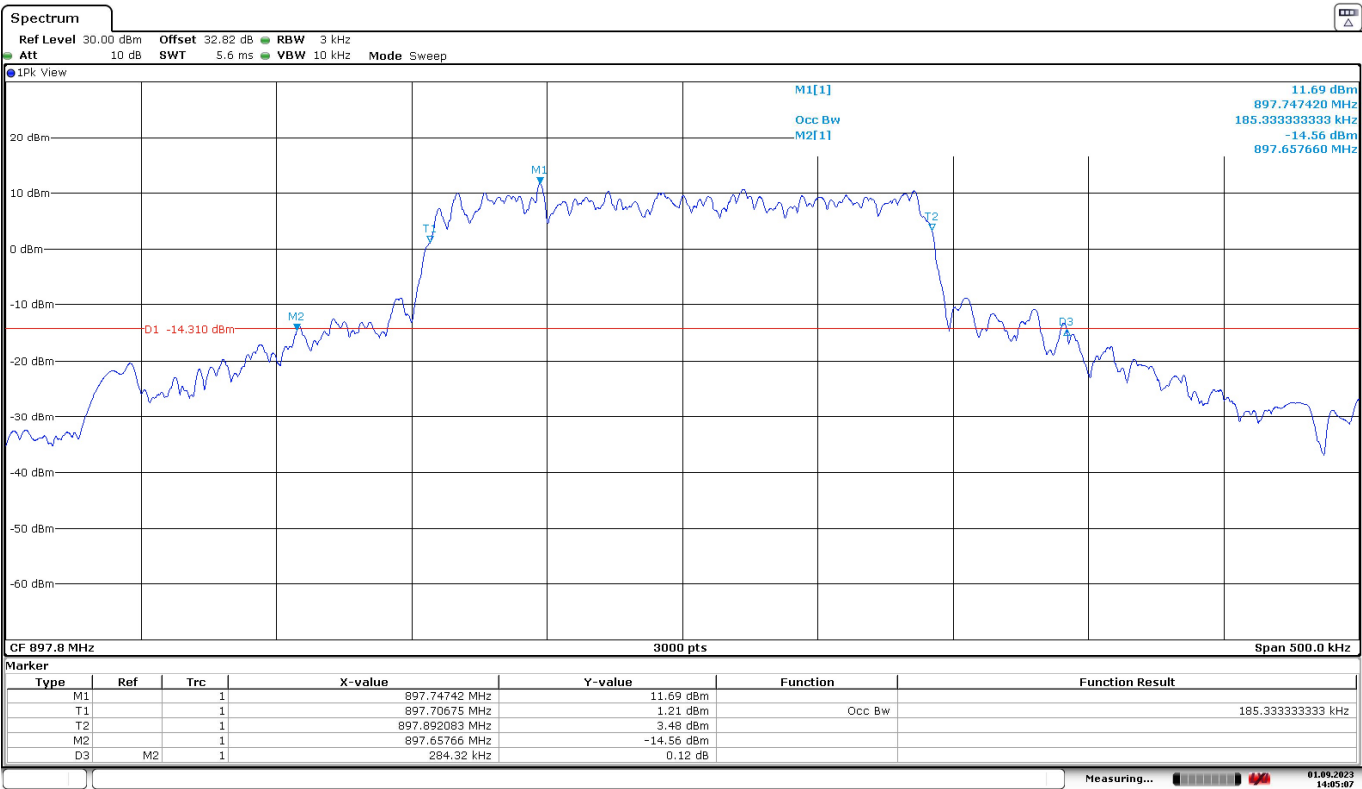


High Channel:



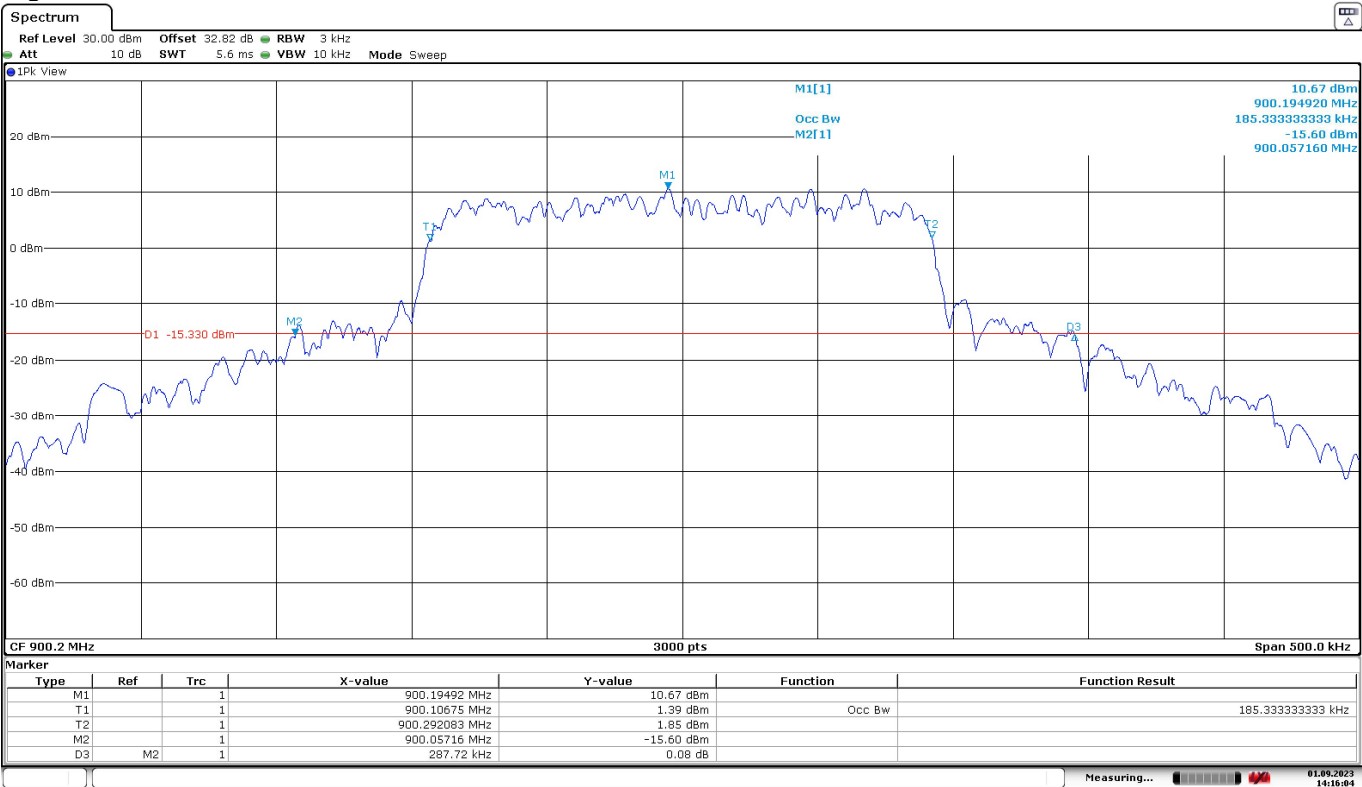
LTE Cat NB1 Band 8. QPSK. BW=15 kHz. Tone Number=12. Tone Offset=0. MSC/TBS=5.

Low Channel:



Date: 1.SEP.2023 14:05:07

High Channel:



Date: 1.SEP.2023 14:16:05

LTE Cat NB1 Band 13:

LTE Cat NB1 Band 13. Pi/2-BPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=23. MSC/TBS=0.

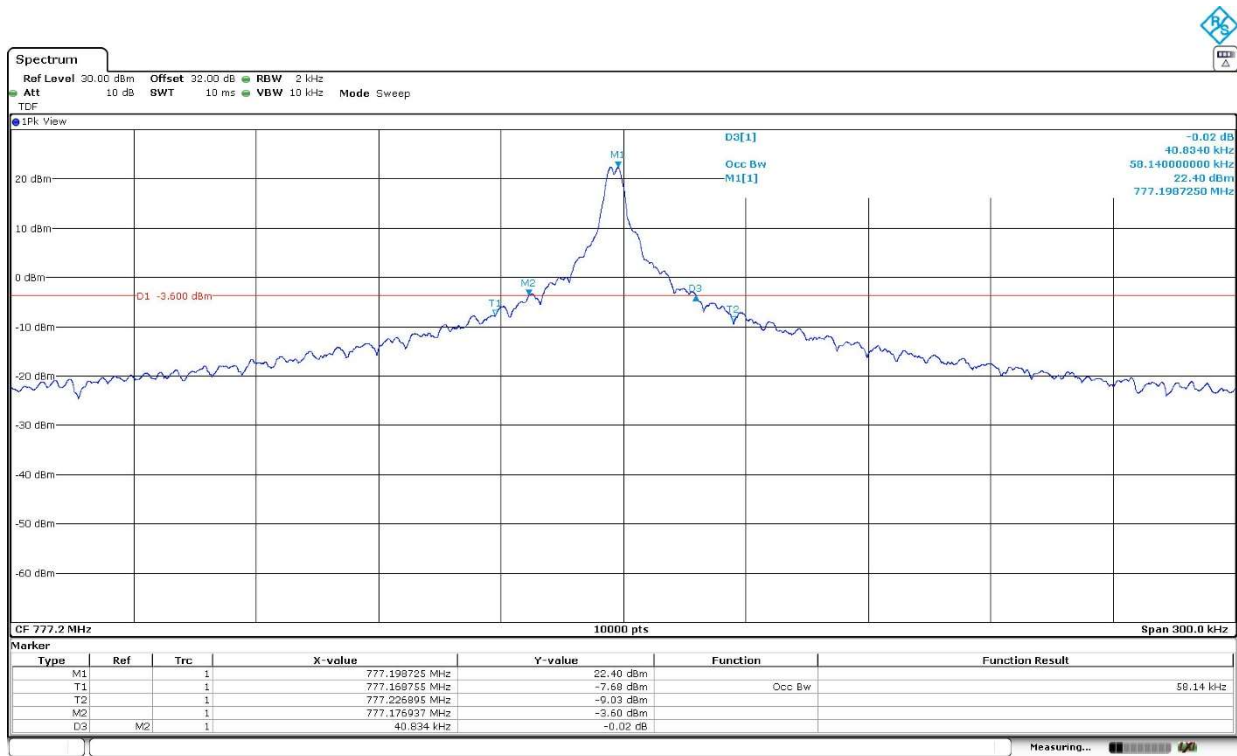
	Low Channel	Middle Channel	High Channel
99% Occupied Bandwidth (kHz)	58.140	59.700	57.780
-26 dBc Bandwidth (kHz)	40.834	39.997	37.560
Measurement uncertainty (kHz)	<±0.35		

LTE Cat NB1 Band 13. Pi/4-QPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=23. MSC/TBS=3.

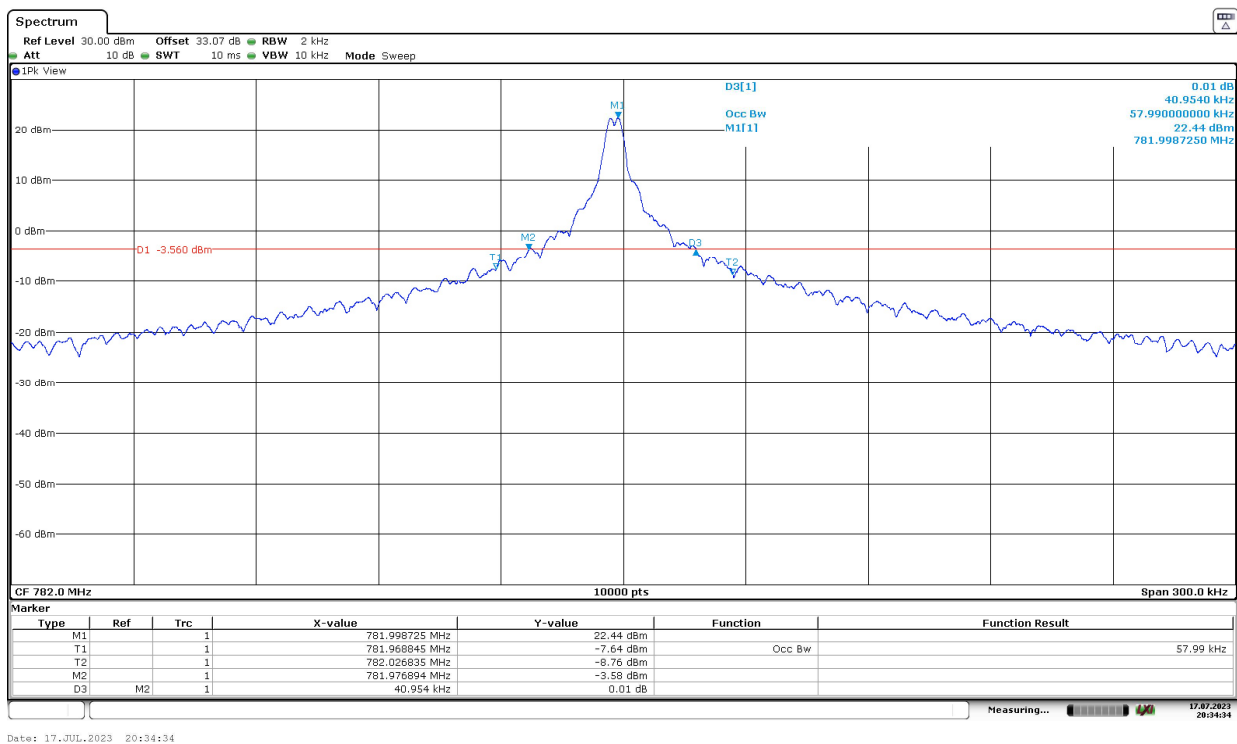
	Low Channel	Middle Channel	High Channel
99% Occupied Bandwidth (kHz)	63.120	57.990	62.940
-26 dBc Bandwidth (kHz)	41.877	40.954	41.830
Measurement uncertainty (kHz)	<±0.35		

LTE Cat NB1 Band 13. Pi/2-BPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=23. MSC/TBS=0.

Low Channel:



Middle Channel:



High Channel:

