

BW=10 MHz. QPSK:

| MAX POWER | QPSK COND. POWER AVG (dBm) | ANTENNA GAIN (dBi) | RAD. POWER AVG EIRP(dBm) |
|-----------|----------------------------|--------------------|--------------------------|
| MIDDLE | 22.77 | 1.56 | 24.33 |
| MAX: | 22.77 | | 24.33 |

BW=10 MHz. 16QAM:

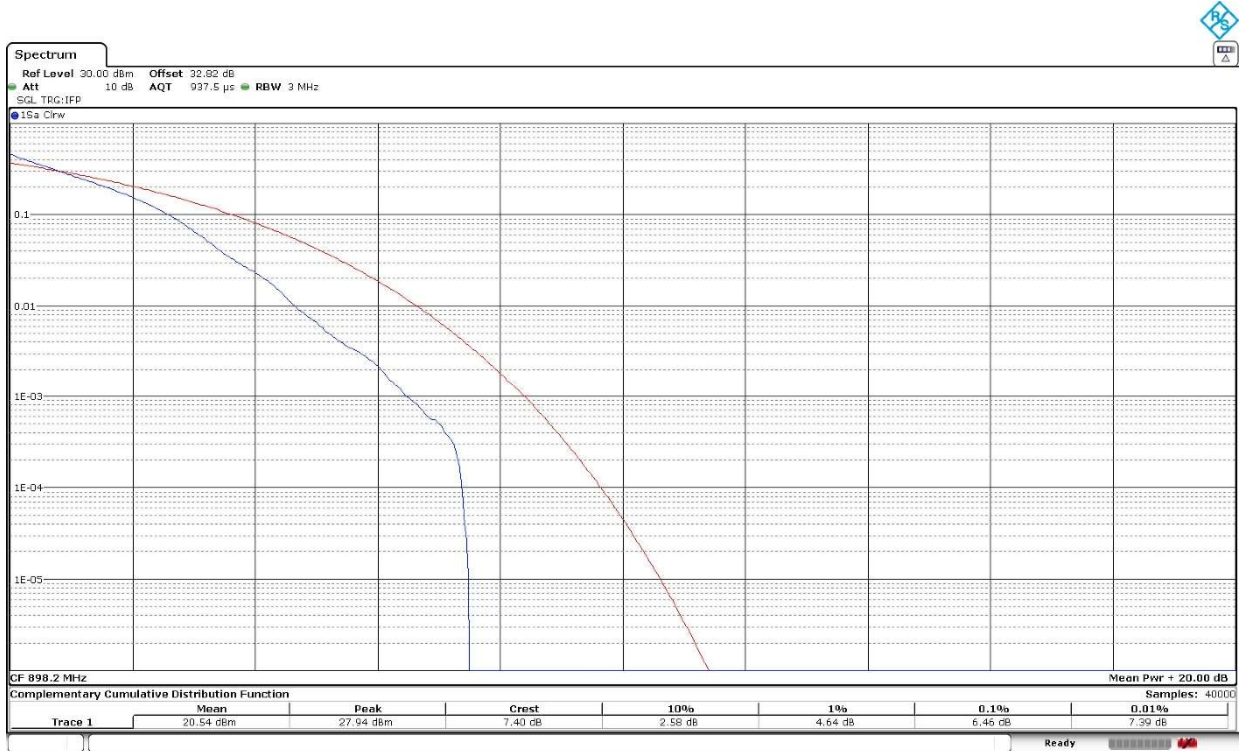
| MAX POWER | 16QAM COND. POWER AVG (dBm) | ANTENNA GAIN (dBi) | RAD. POWER AVG EIRP(dBm) |
|-----------|-----------------------------|--------------------|--------------------------|
| MIDDLE | 23.41 | 1.56 | 24.97 |
| MAX: | 23.41 | | 24.97 |

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

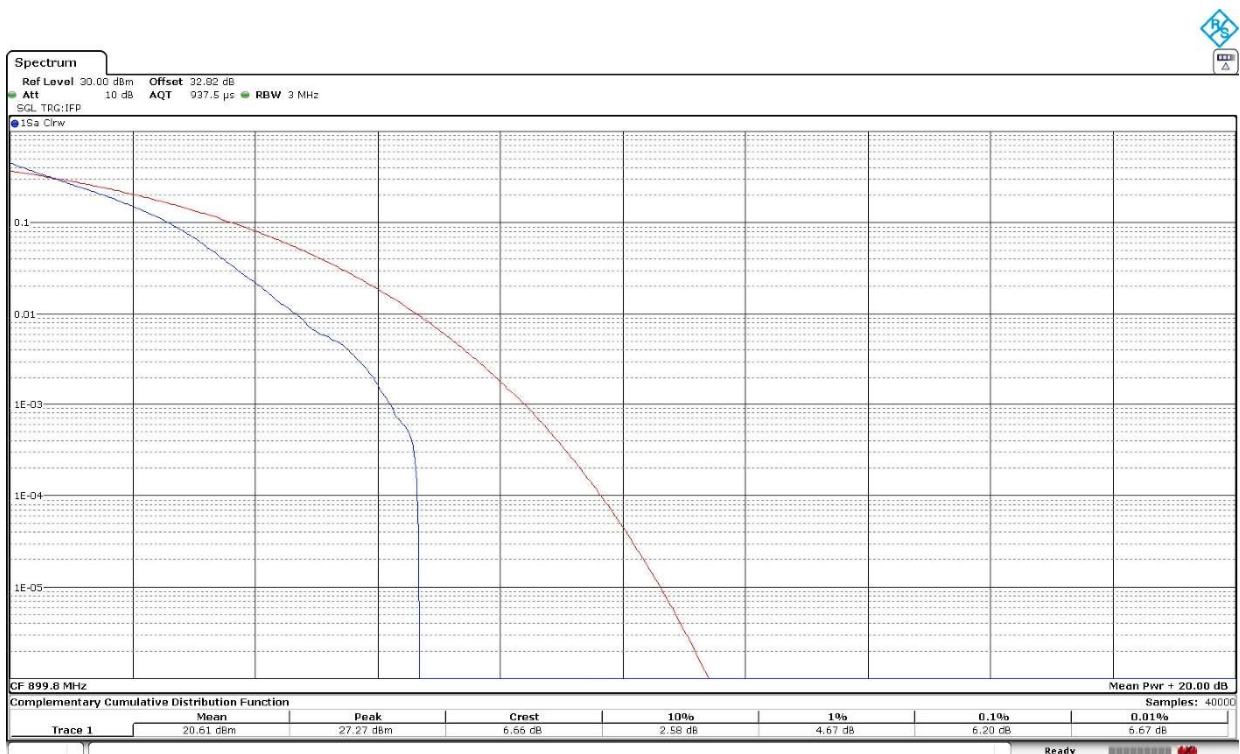
LTE Cat-M1 Band 8:

Worst-case of PAPR is BW=1.4 MHz, Low Channel, QPSK, RB Size=6, RB Offset=0, Narrow Band=0.

Low Channel:



High Channel:



| | | |
|-----------|------|------|
| QPSK | Low | High |
| PAPR (dB) | 6.46 | 6.20 |

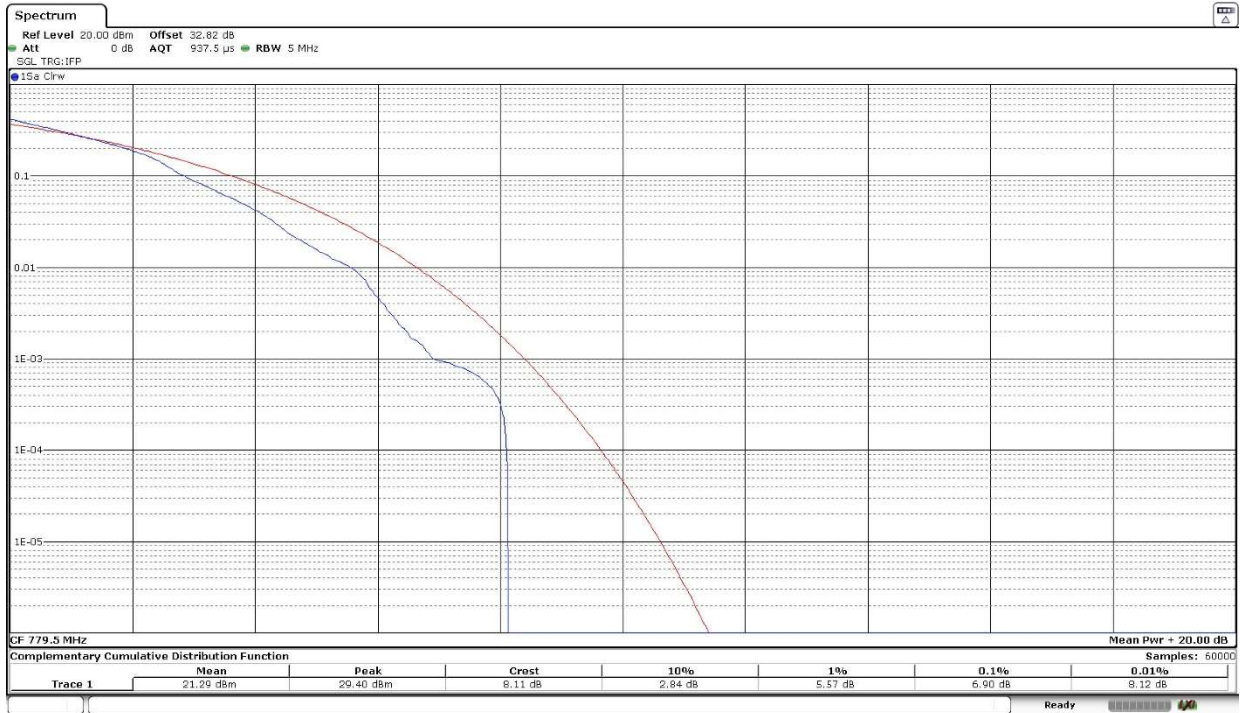
Verdict

Pass

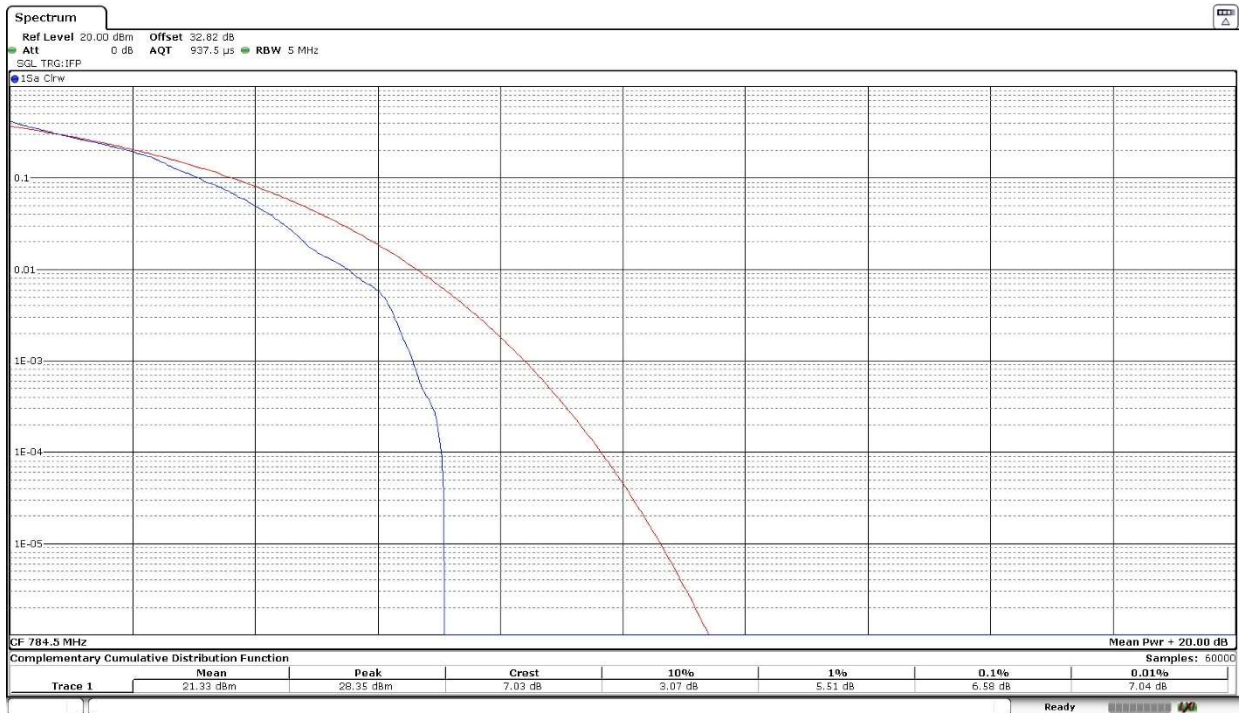
LTE Cat-M1 Band 13:

Worst-case of PAPR is BW= 5 MHz, Low Channel, 16QAM, RB Size=3, RB Offset=1, Narrow Band=1.

Low Channel:



High Channel:



| 16QAM | Low | High |
|-----------|-----|------|
| PAPR (dB) | 6.9 | 6.58 |

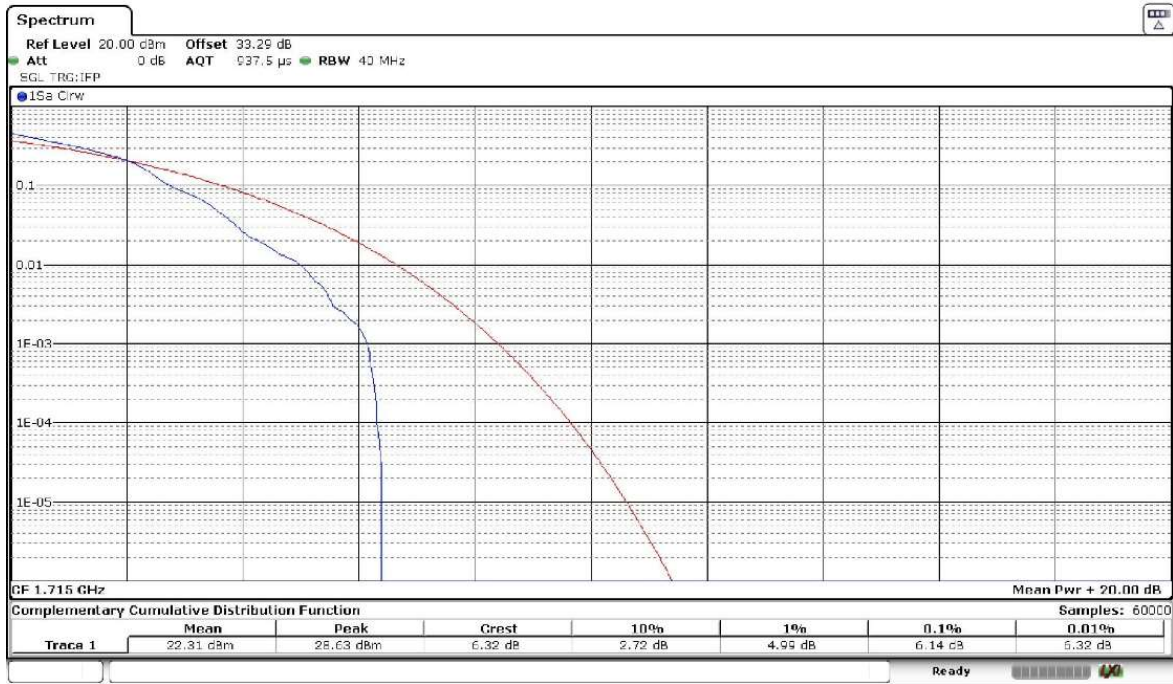
Verdict

Pass

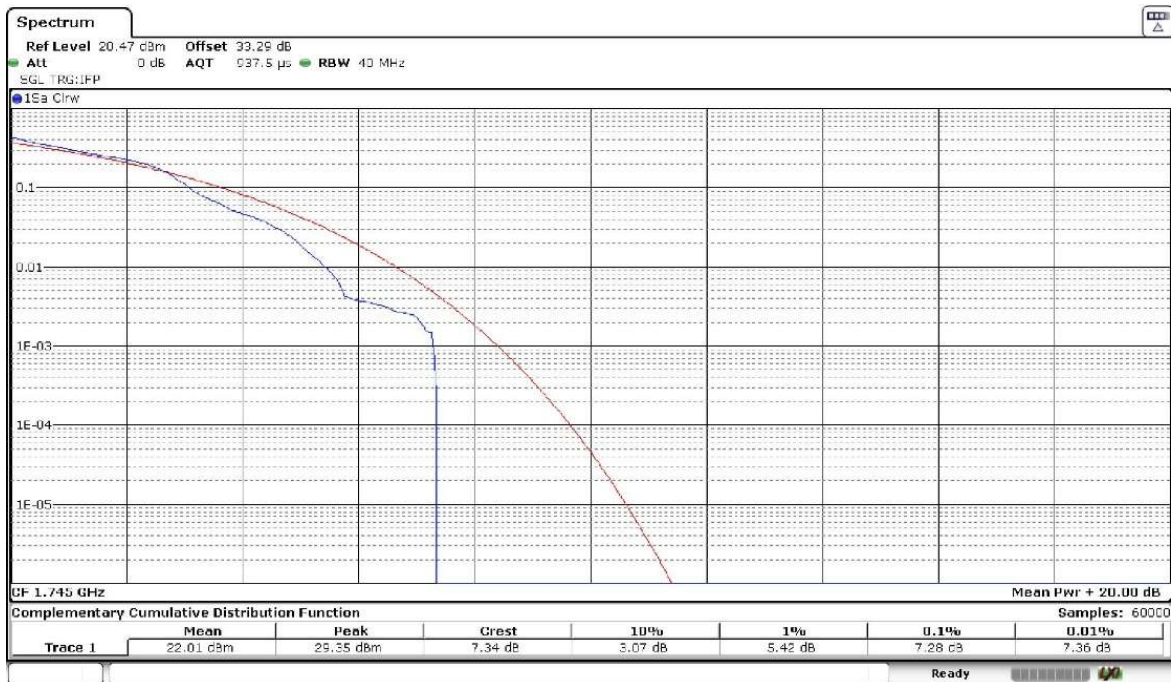
LTE Cat-M1 Band 66:

Worst-case of PAPR is BW= 10 MHz, Middle Channel, 16QAM, RB Size=1, RB Offset=5, Narrow Band=0.

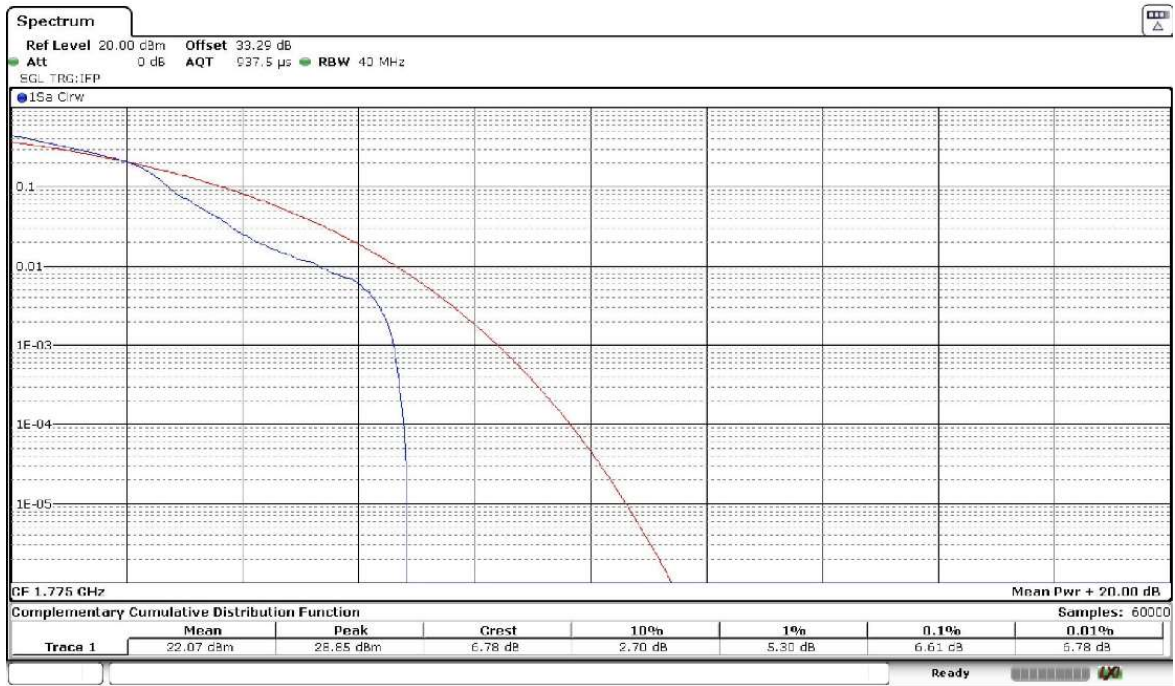
Low Channel:



Middle Channel:



High Channel:



| 16QAM | Low | Middle | High |
|-----------|------|--------|------|
| PAPR (dB) | 6.14 | 7.28 | 6.61 |

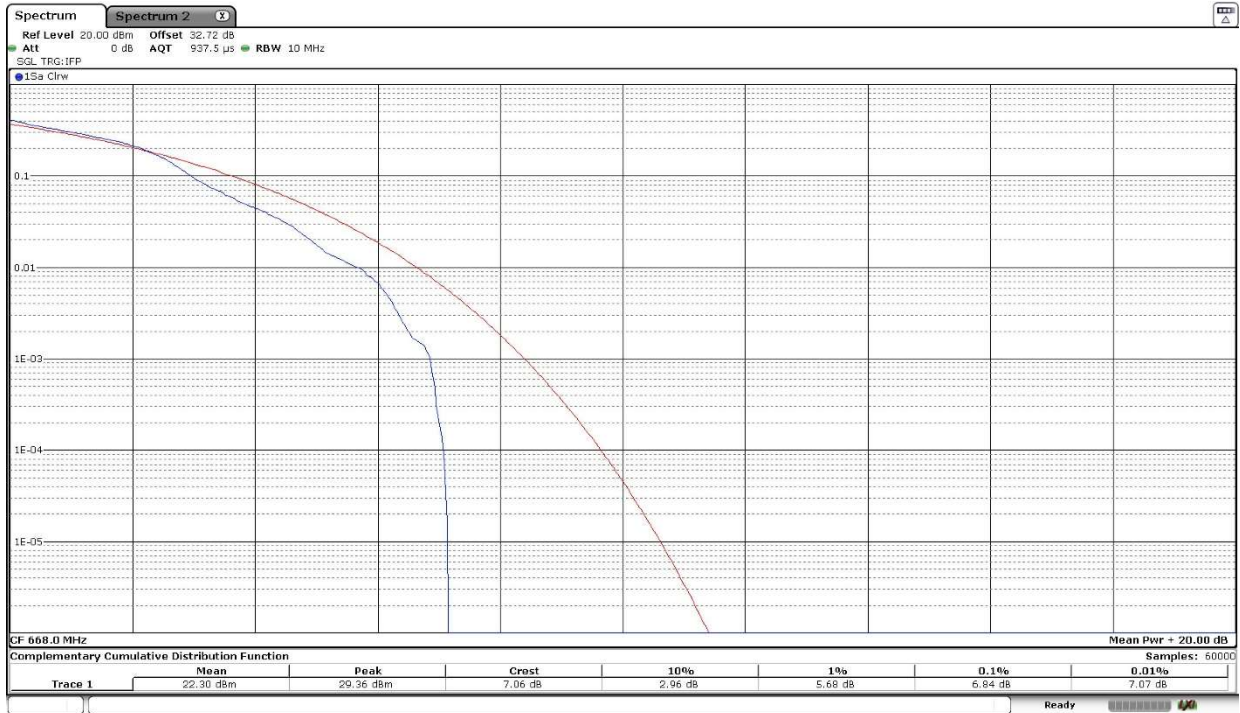
Verdict

Pass

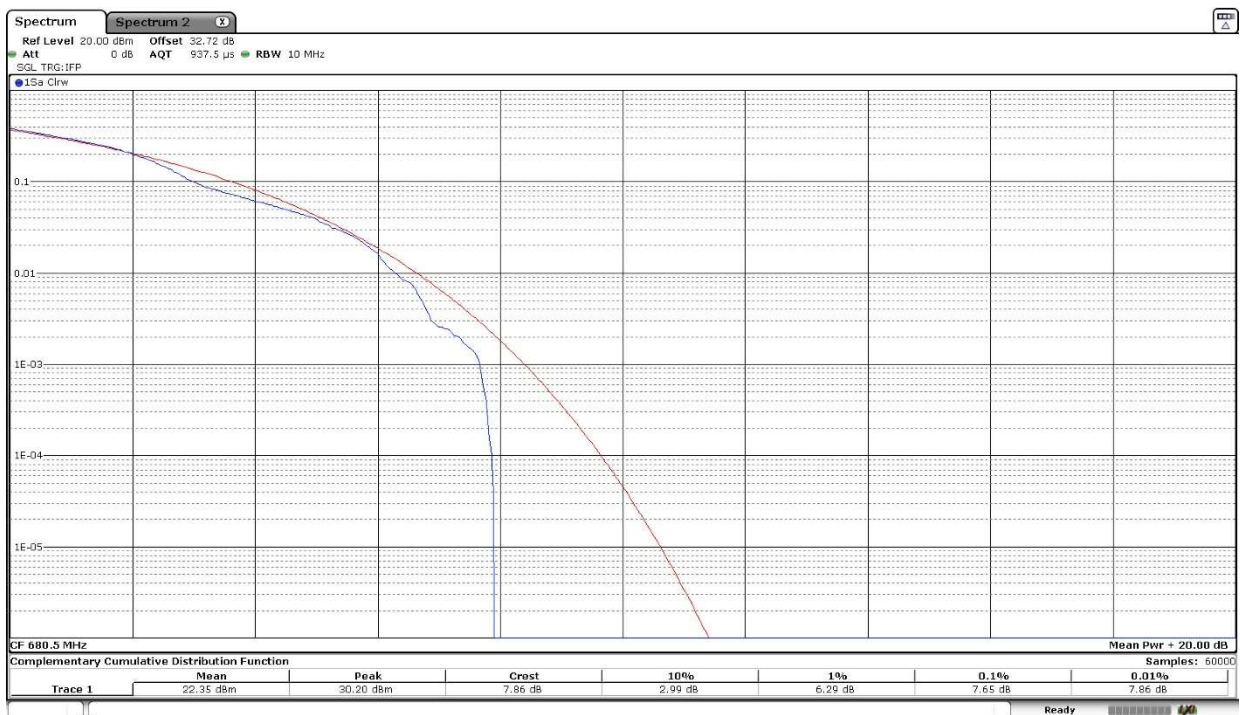
LTE Cat-M1 Band 71:

Worst-case of PAPR is BW= 10 MHz, Middle Channel, 16QAM, RB Size=1, RB Offset=5, Narrow Band=3.

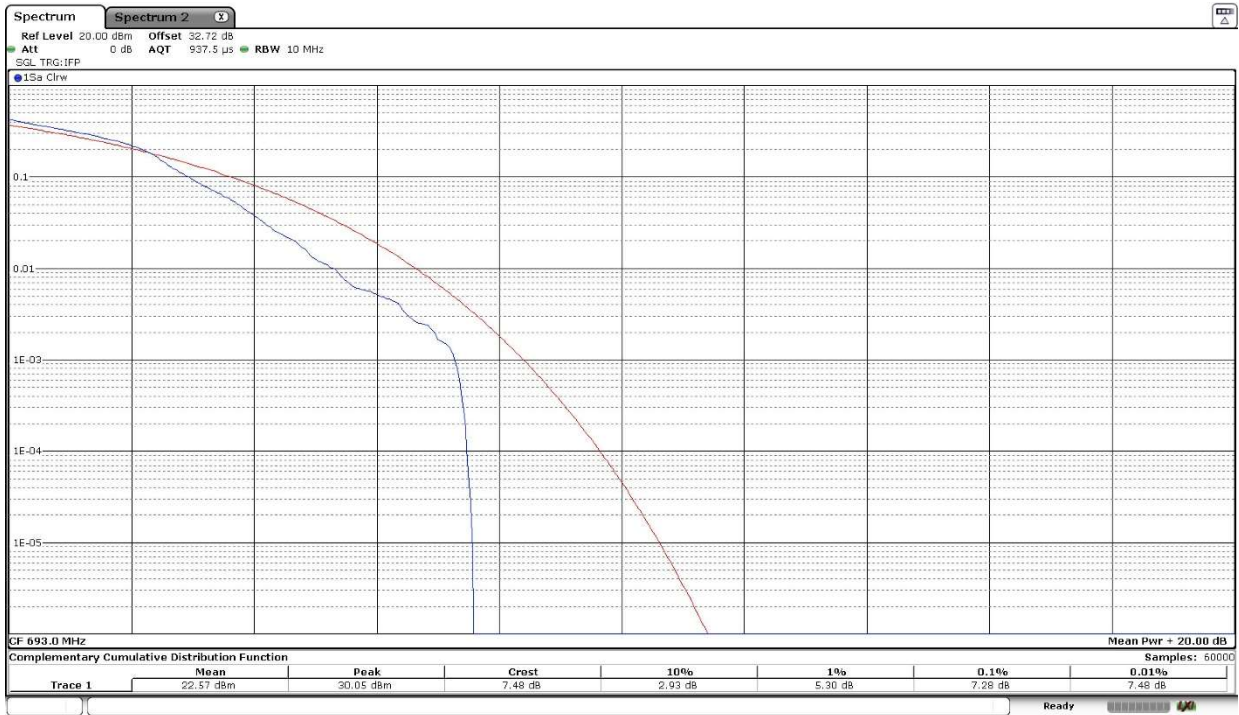
Low Channel:



Middle Channel:



High Channel:



| 16QAM | Low | Middle | High |
|-----------|------|--------|------|
| PAPR (dB) | 6.84 | 7.65 | 7.28 |

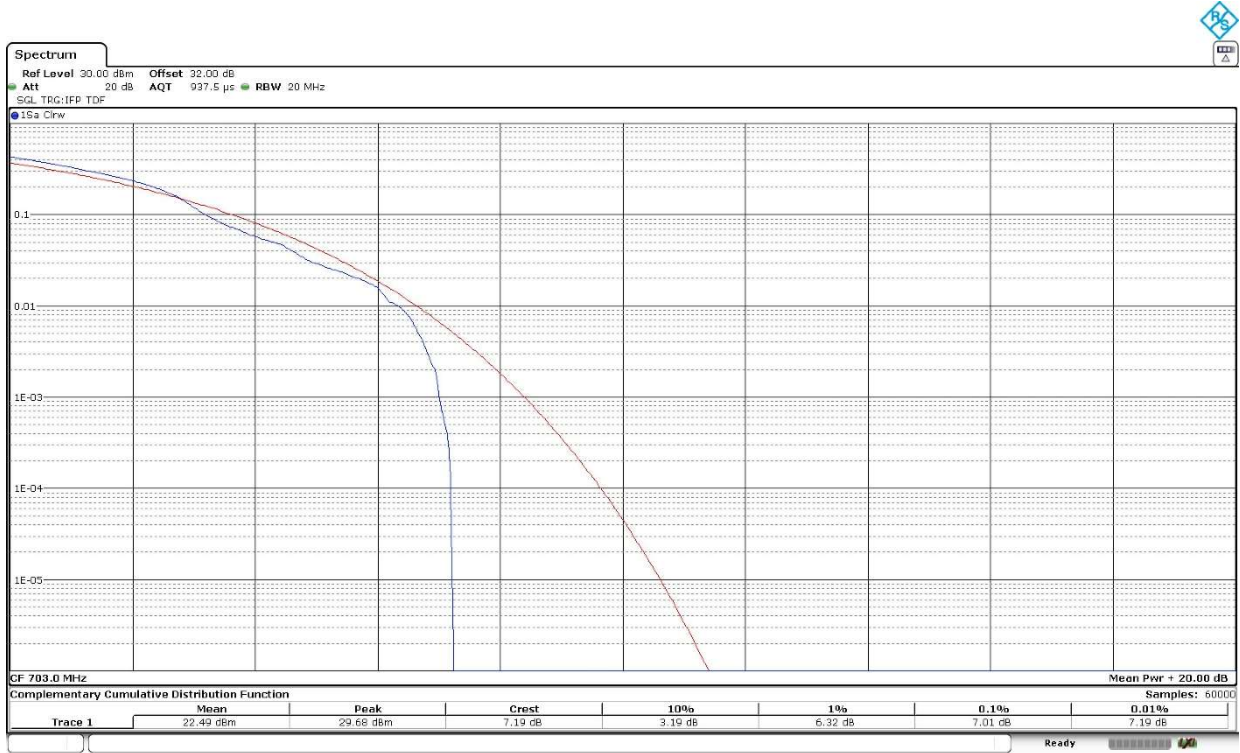
Verdict

Pass

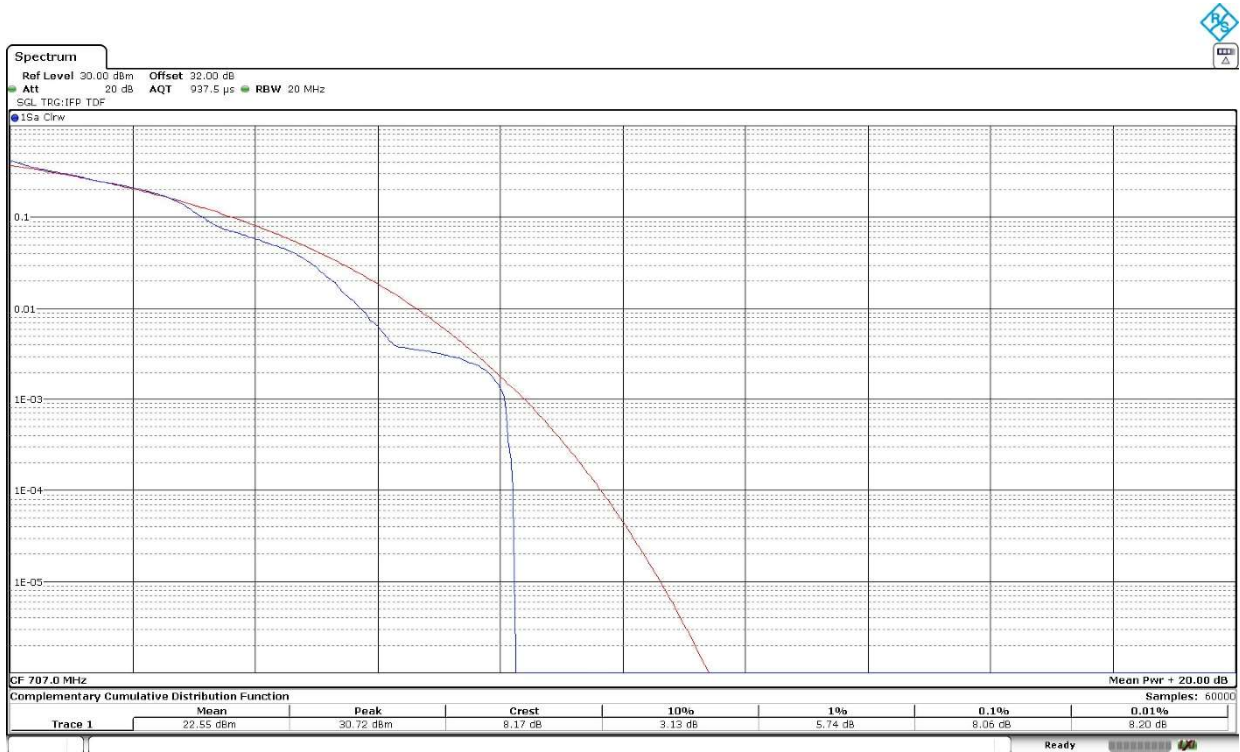
LTE Cat-M1 Band 85:

Worst-case of PAPR is BW=10 MHz, Middle Channel, 16QAM, RB Size=1, RB Offset=2, Narrow Band=0.

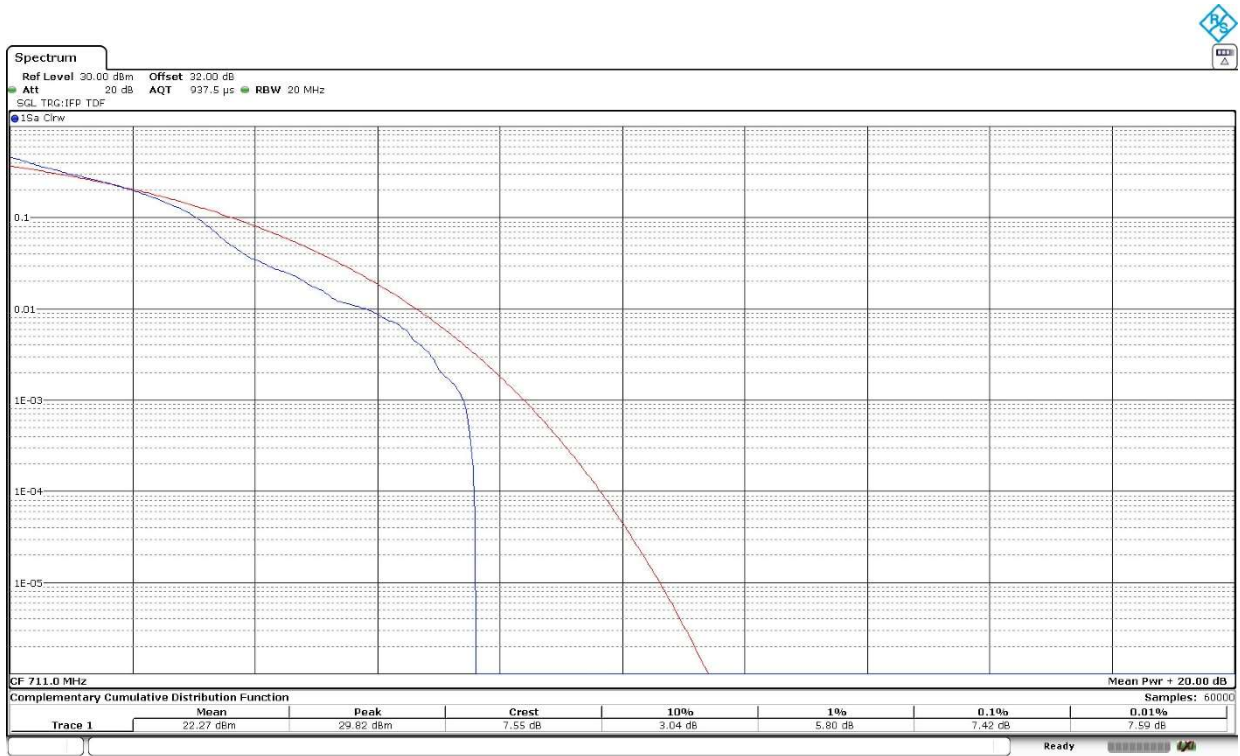
Low Channel:



Middle Channel:



High Channel:



| | Low | Middle | High |
|-----------|------|--------|------|
| 16QAM | | | |
| PAPR (dB) | 7.01 | 8.06 | 7.42 |

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, 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.

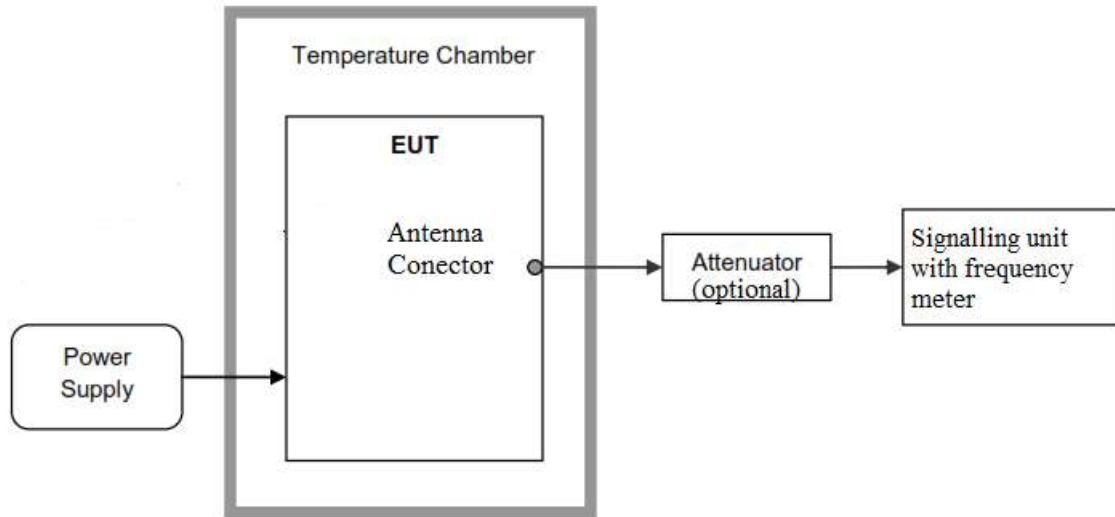
The worst case LTE mode for conducted power was used for the test.

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.

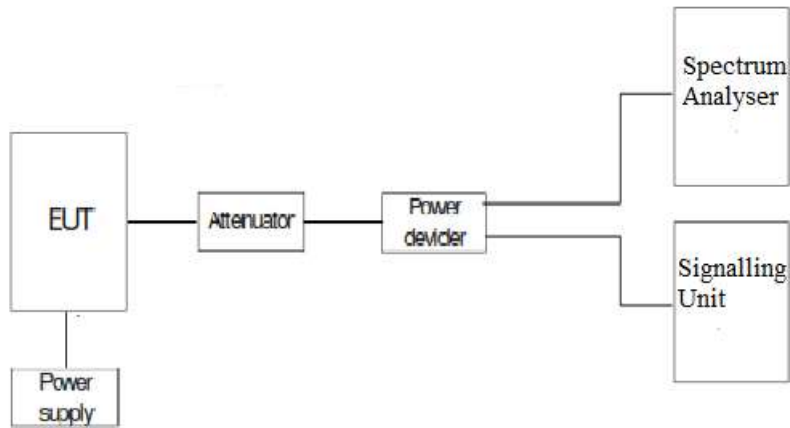
The reference point measurements were made at the RF output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

Test Setup

Frequency tolerance:



Reference points f_L and f_H :



Results

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 (°C) | Frequency Error (Hz) | Frequency Error (ppm) |
|------------------|----------------------|-----------------------|
| +85 | 4,58 | 0,005101359 |
| +80 | 7,56 | 0,008420584 |
| +70 | 1,78 | 0,001982624 |
| +60 | 2,62 | 0,002918245 |
| +50 | 3,28 | 0,003653375 |
| +40 | 3,78 | 0,004210292 |
| +30 | 4,9 | 0,005457786 |
| +20 | 3,45 | 0,003842727 |
| +10 | 8,58 | 0,009556694 |
| 0 | -2,44 | -0,002717755 |
| -10 | 2,64 | 0,002940521 |
| -20 | -1,19 | -0,001325462 |
| -30 | -0,71 | -0,000790822 |
| -40 | -1,42 | -0,001581644 |

LTE Cat-M1 Band 13:

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

| Temperature (°C) | Frequency Error (Hz) | Frequency Error (ppm) |
|------------------|----------------------|-----------------------|
| 85 | -0,9 | -0,001150895 |
| 80 | 4,64 | 0,005933504 |
| 70 | -5,45 | -0,006969309 |
| 60 | -1,45 | -0,00185422 |
| +50 | 4,71 | 0,006023018 |
| +40 | -6,38 | -0,008158568 |
| +30 | 5,75 | 0,007352941 |
| +20 | 0,7 | 0,000895141 |
| +10 | -4,61 | -0,005895141 |
| 0 | 4,15 | 0,005306905 |
| -10 | -5,62 | -0,007186701 |
| -20 | 4,63 | 0,005920716 |
| -30 | -8,41 | -0,010754476 |
| -40 | 5,26 | 0,006726343 |

LTE Cat-M1 Band 66:

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

| Temperature (°C) | Frequency Error (Hz) | Frequency Error (ppm) |
|------------------|----------------------|-----------------------|
| +85 | 7,34 | 0,004206304 |
| +80 | 6,5 | 0,003724928 |
| +70 | 3,4 | 0,001948424 |
| +60 | -2,7 | -0,001547278 |
| +50 | 8,8 | 0,00504298 |

| | | |
|-----|-------|--------------|
| +40 | 4.52 | 0.002590258 |
| +30 | 3.18 | 0.00182235 |
| +20 | 2.8 | 0.001604585 |
| +10 | 3.63 | 0.002080229 |
| 0 | 2.59 | 0.001484241 |
| -10 | 0.56 | 0.000320917 |
| -20 | 1.13 | 0.000647564 |
| -30 | -0.74 | -0.000424069 |
| -40 | -1,73 | -0,000991404 |

LTE Cat-M1 Band 71:

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

| Temperature (°C) | Frequency Error (Hz) | Frequency Error (ppm) |
|------------------|----------------------|-----------------------|
| +85 | 0,94 | 0,001381337 |
| +80 | 4,64 | 0,006818516 |
| +70 | -5,45 | -0,008008817 |
| +60 | -1,45 | -0,002130786 |
| +50 | -2,33 | -0,003423953 |
| +40 | -4,18 | -0,006142542 |
| +30 | -5,12 | -0,00752388 |
| +20 | -4,29 | -0,006304188 |
| +10 | -4,71 | -0,006921381 |
| 0 | -5,56 | -0,008170463 |
| -10 | -0,82 | -0,001204996 |
| -20 | -8,93 | -0,013122704 |
| -30 | -5,66 | -0,008317414 |
| -40 | -6,54 | -0,00961058 |

LTE Cat-M1 Band 85:

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

| Temperature (°C) | Frequency Error (Hz) | Frequency Error (ppm) |
|------------------|----------------------|-----------------------|
| +85 | 6,65 | 0,009405941 |
| +80 | 3,23 | 0,0045686 |
| +70 | -2,1 | -0,002970297 |
| +60 | -5,98 | -0,008458274 |
| +50 | 6,77 | 0,009575672 |
| +40 | 1,32 | 0,001867044 |
| +30 | -6,34 | -0,008967468 |
| +20 | -3,56 | -0,005035361 |
| +10 | 4,03 | 0,005700141 |
| 0 | 4,73 | 0,00669024 |
| -10 | 4,45 | 0,006294201 |
| -20 | 7,02 | 0,009929279 |
| -30 | -4,68 | -0,006619519 |
| -40 | -5,97 | -0,00844413 |

- **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 | 3,57 | 0,003976387 |
| Vmin | 3 | 6,73 | 0,007496102 |

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 | -11.03 | -0.014104859 |
| Vmin | 3 | 4,68 | 0,005984655 |

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 | 3.56 | 0.002040115 |
| Vmin | 3 | -6,07 | -0,00347851 |

LTE Cat-M1 Band 71:

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 | -14.81 | -0.021763409 |
| Vmin | 3 | -3,49 | -0,005128582 |

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 | -7.34 | -0.010381895 |
| Vmin | 3 | 2,11 | 0,002984441 |

2. REFERENCE FREQUENCY POINTS f_L AND f_H :

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

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

| | |
|-------------|----------|
| f_L (MHz) | 897.5056 |
| f_H (MHz) | 900.4939 |

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

| | |
|-------------|----------|
| f_L (MHz) | 777.1118 |
| f_H (MHz) | 786.8815 |

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

| | |
|-------------|-----------|
| f_L (MHz) | 1710.0057 |
| f_H (MHz) | 1779.9943 |

LTE Cat-M1 Band 71: BW=5 MHz. QPSK.

| | |
|-------------|----------|
| f_L (MHz) | 663.0375 |
| f_H (MHz) | 697.9558 |

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

| | |
|-------------|----------|
| f_L (MHz) | 698.0844 |
| f_H (MHz) | 715.9678 |

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

Measurement uncertainty (Hz): $<\pm 207.77$

Verdict

PASS

Modulation Characteristics

Limits

FCC §2.1047.

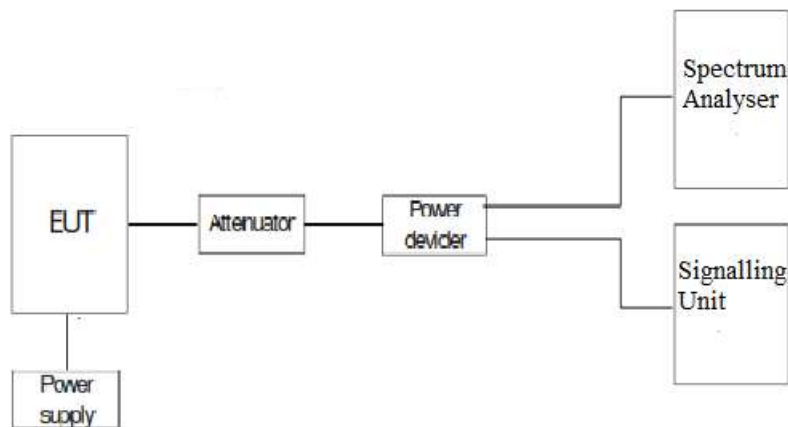
RSS-130, Clause 4.2: Equipment certified under this standard shall employ digital modulation.

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 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

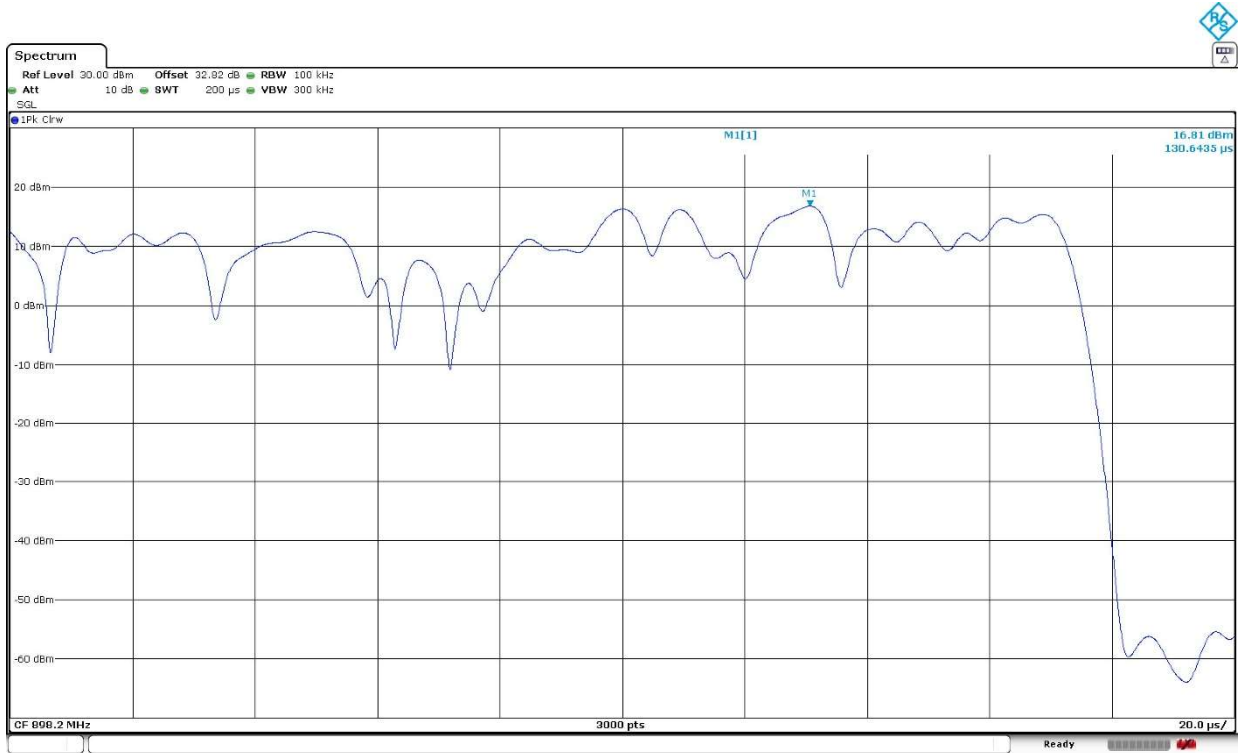


Results

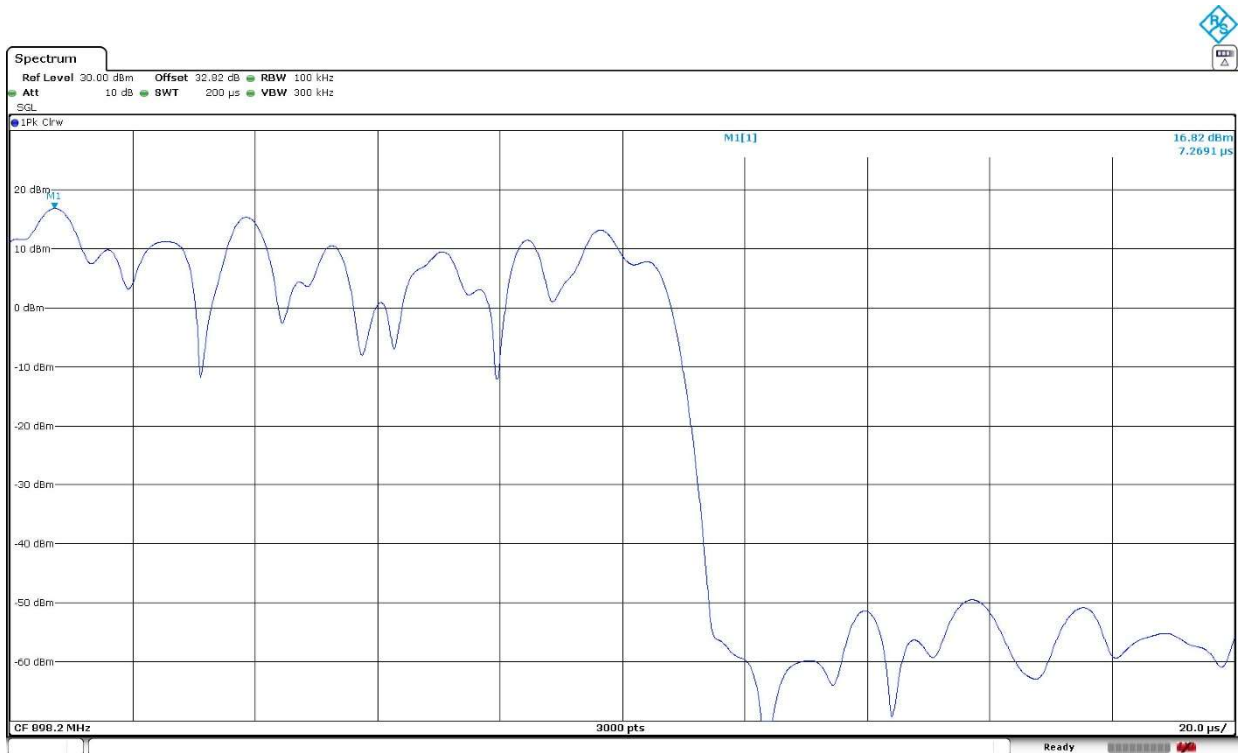
The following plots show the modulation schemes in the EUT.

LTE Cat-M1 Band 8:

QPSK. BW=1.4 MHz.

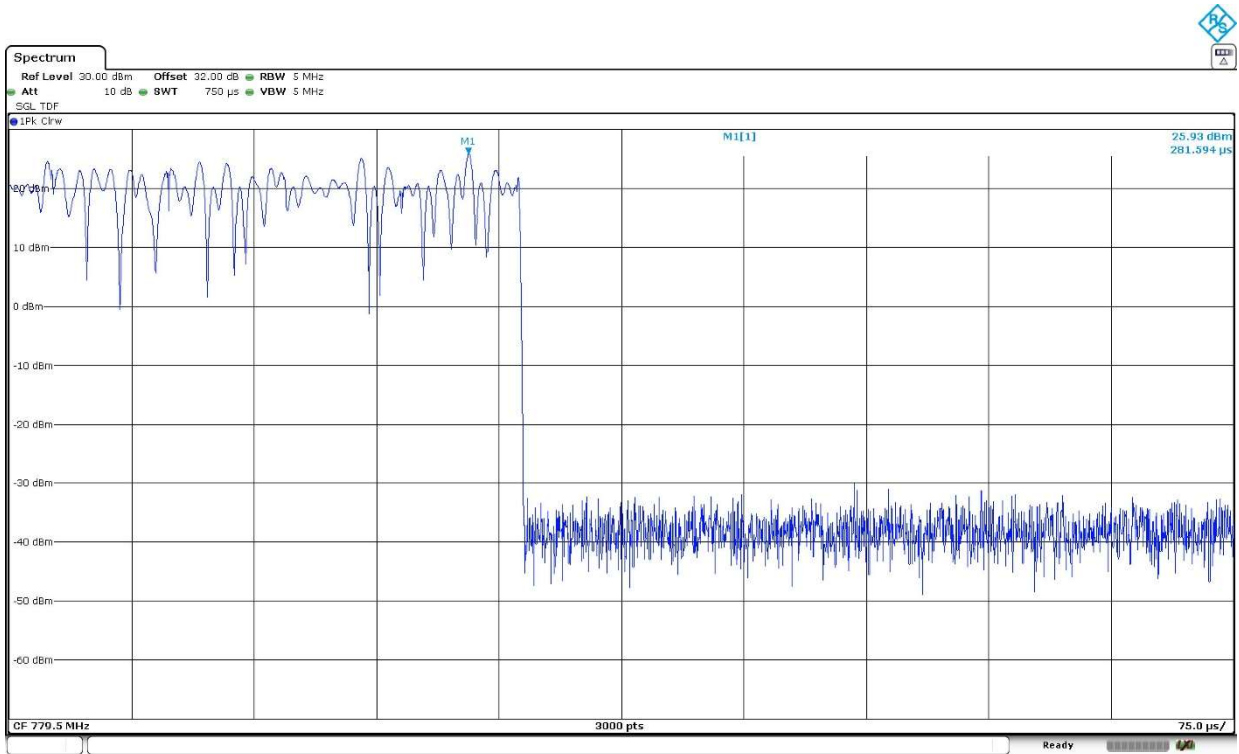


16QAM. BW=1.4 MHz.

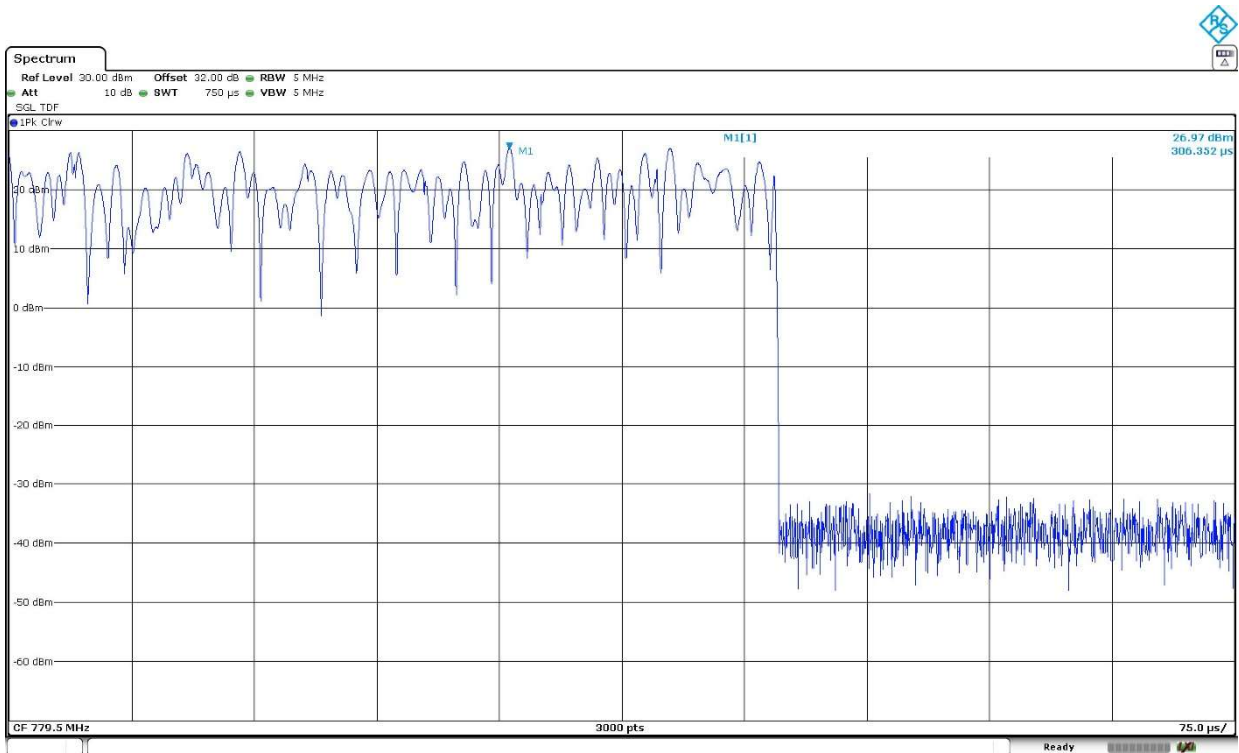


LTE Cat-M1 Band 13:

QPSK. BW=5 MHz.

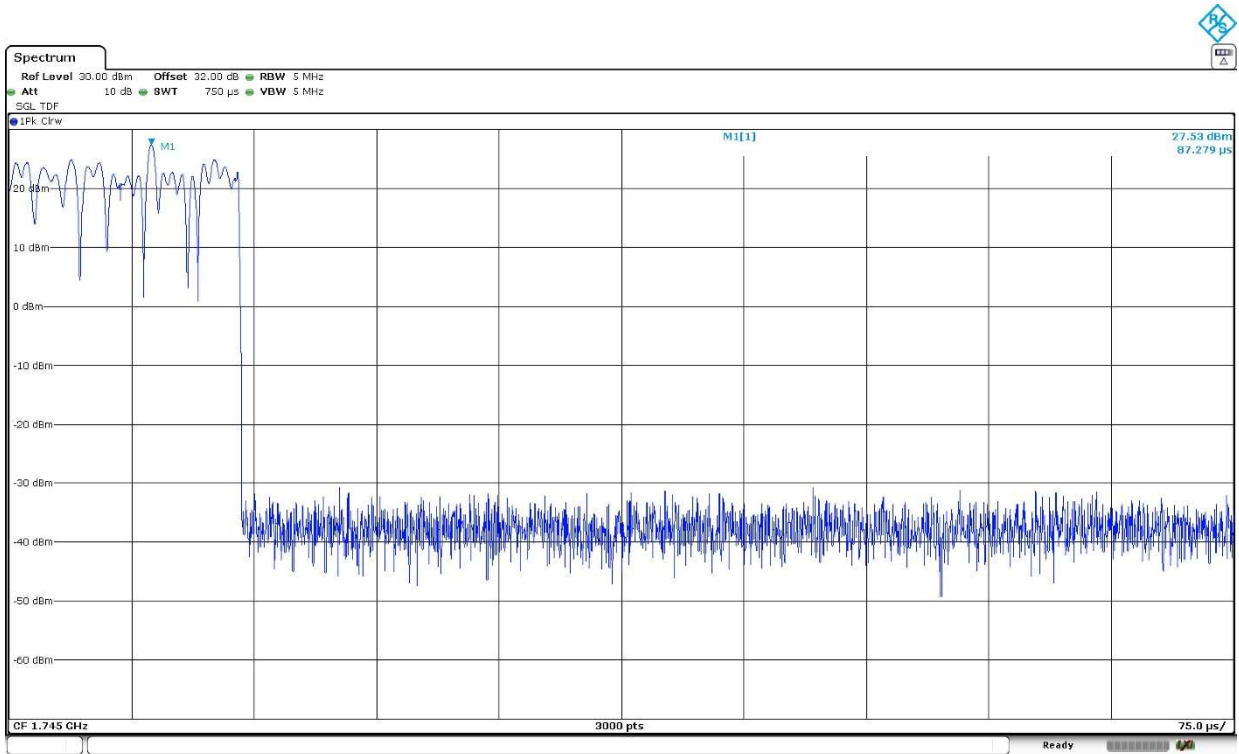


16QAM. BW=5 MHz.

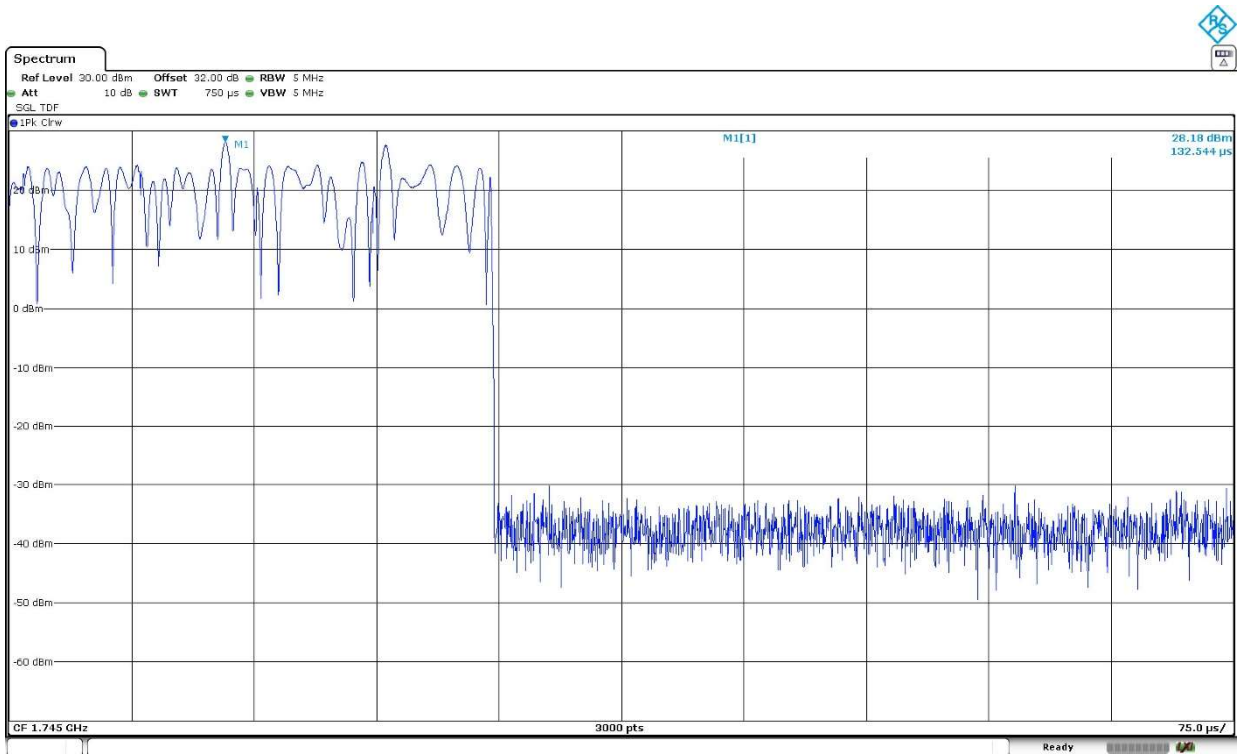


LTE Cat-M1 Band 66:

QPSK. BW=1.4 MHz.

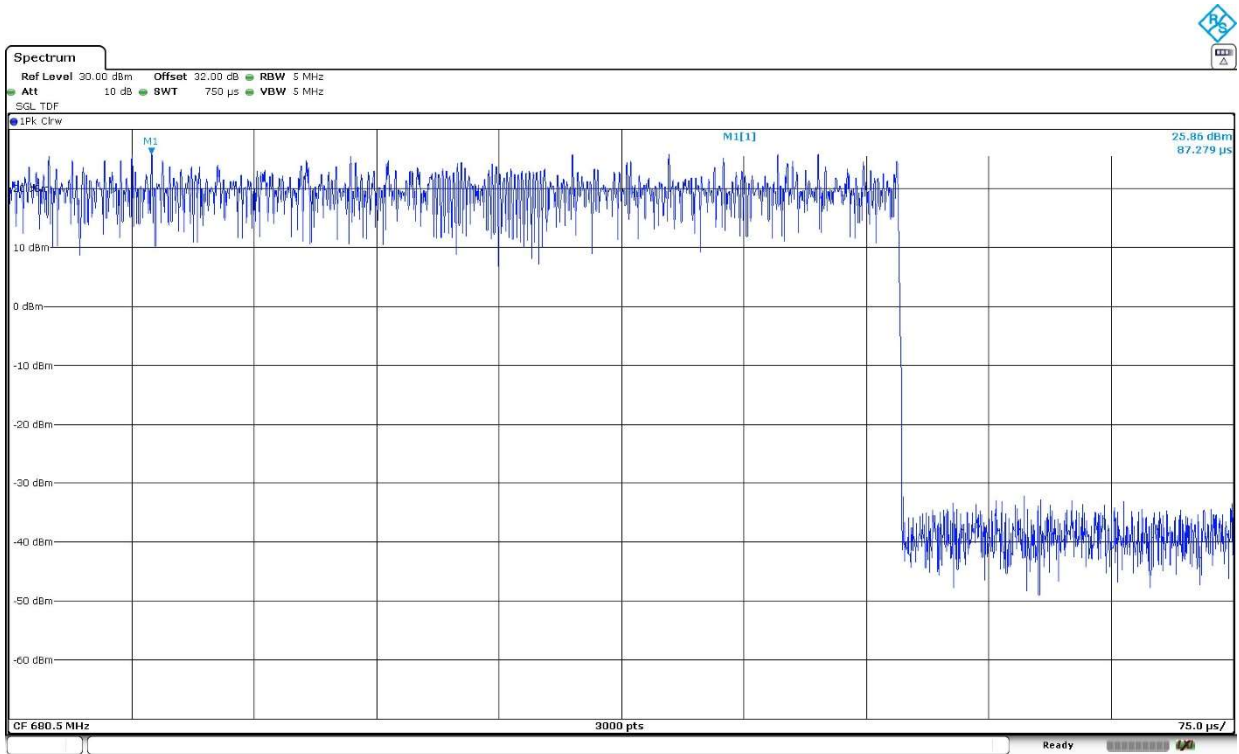


16QAM. BW=1.4 MHz.

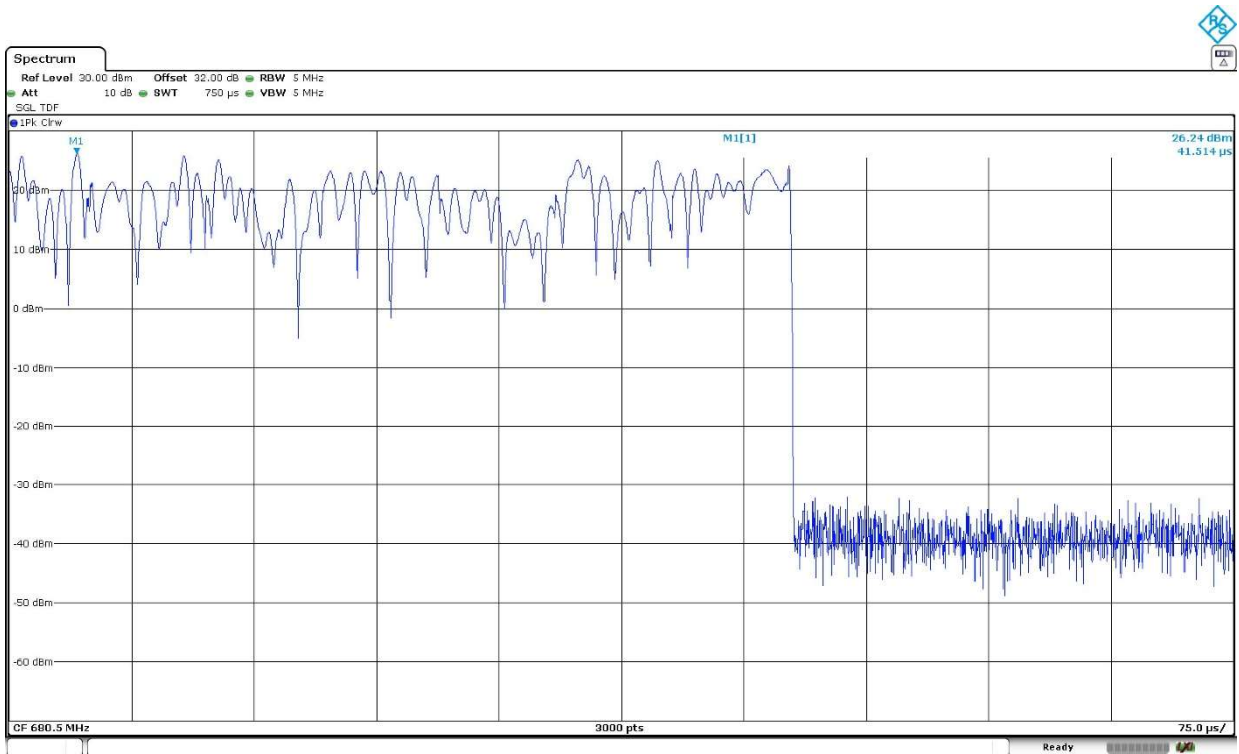


LTE Cat-M1 Band 71:

QPSK. BW=5 MHz.

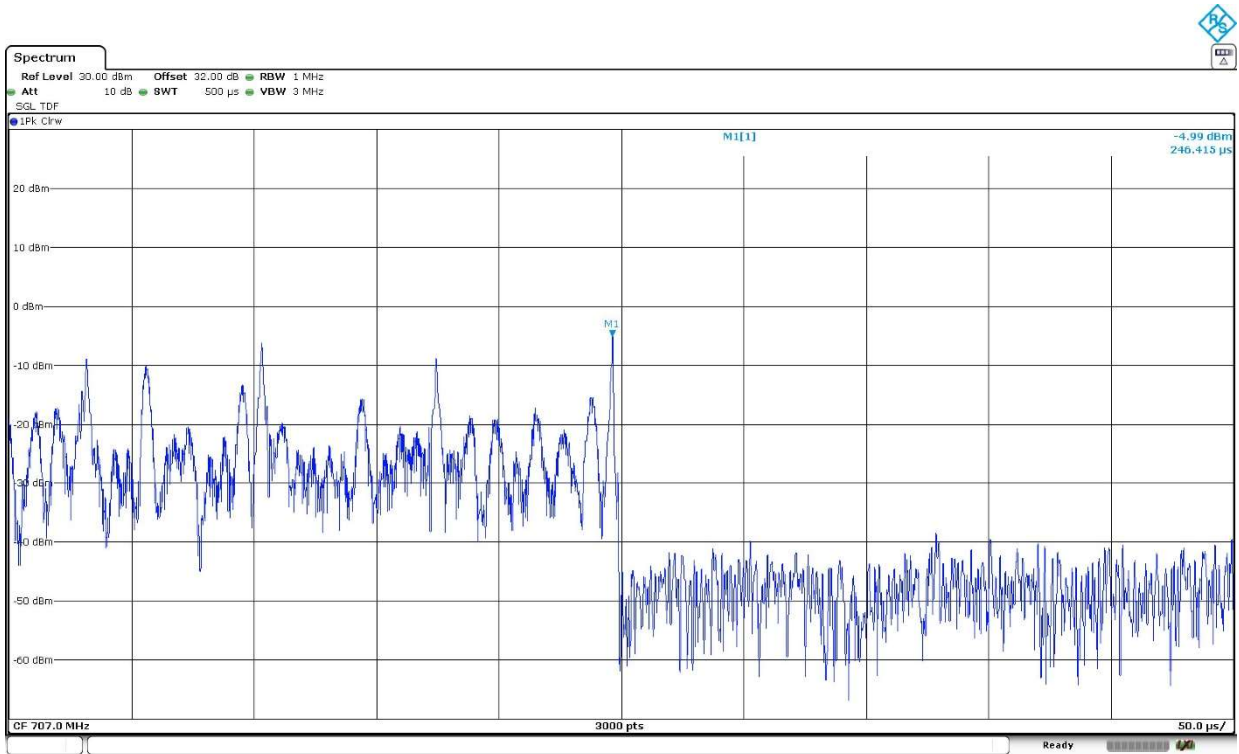


16QAM. BW=5 MHz.

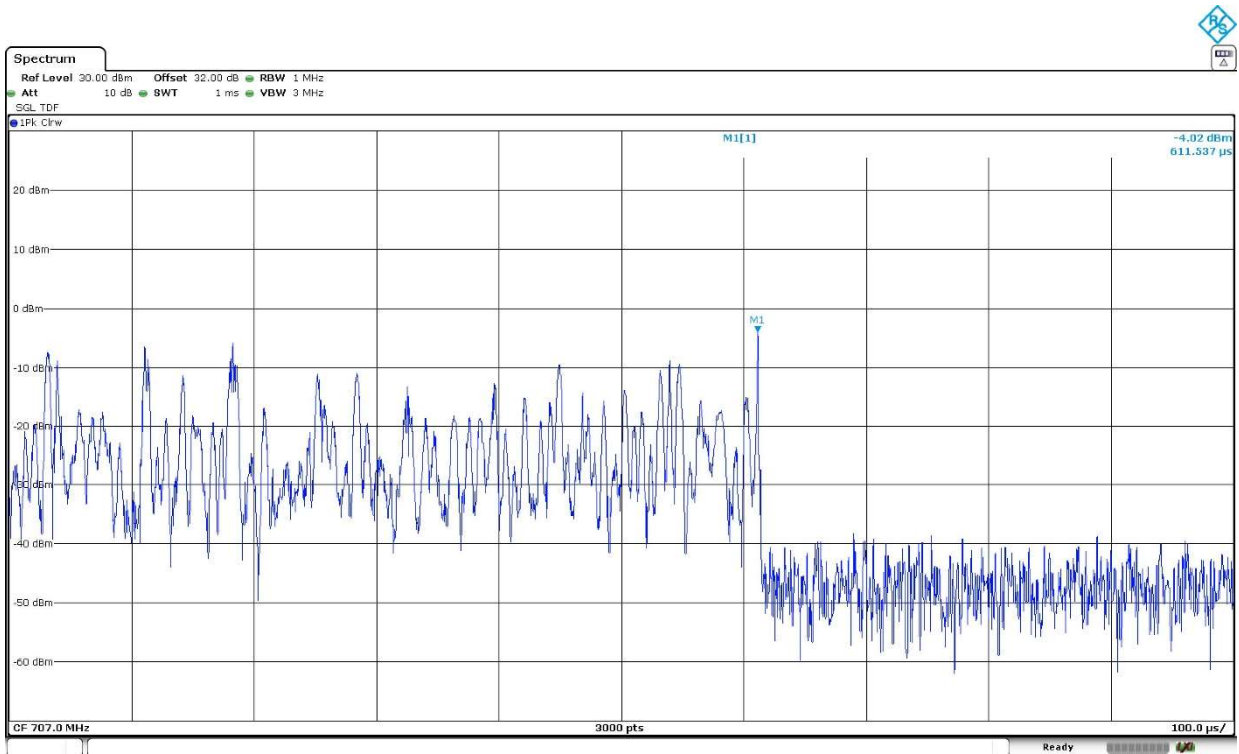


LTE Cat-M1 Band 85:

QPSK. BW=5 MHz.



16QAM. BW=5 MHz.



Occupied Bandwidth

Limits

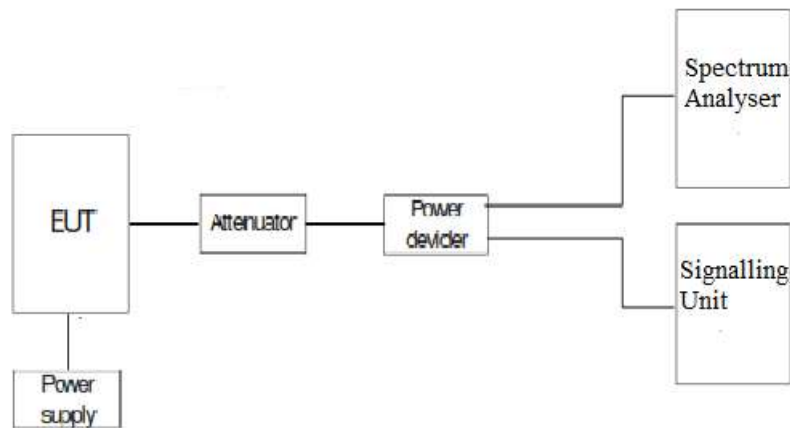
FCC §2.1049: Measurements required: Occupied bandwidth.

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 all Resource Blocks (RB) offset 0 regardless either the Narrow Band 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) | 1.109 | 1.111 |
| -26 dBc Bandwidth (MHz) | 1.401 | 1.413 |
| 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) | 0.951 | 0.949 |
| -26 dBc Bandwidth (MHz) | 1.312 | 1.321 |
| Measurement uncertainty (kHz) | <±3.75 | |