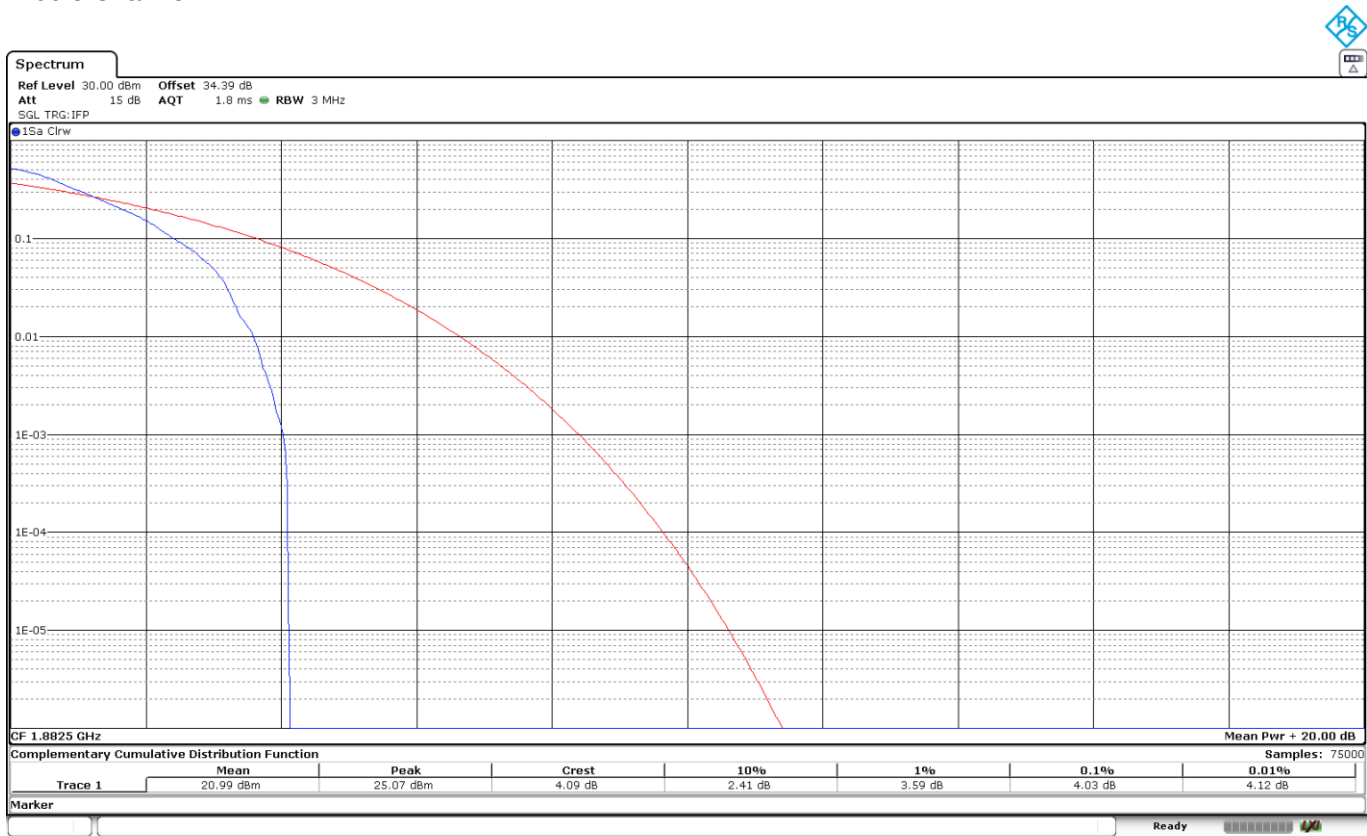
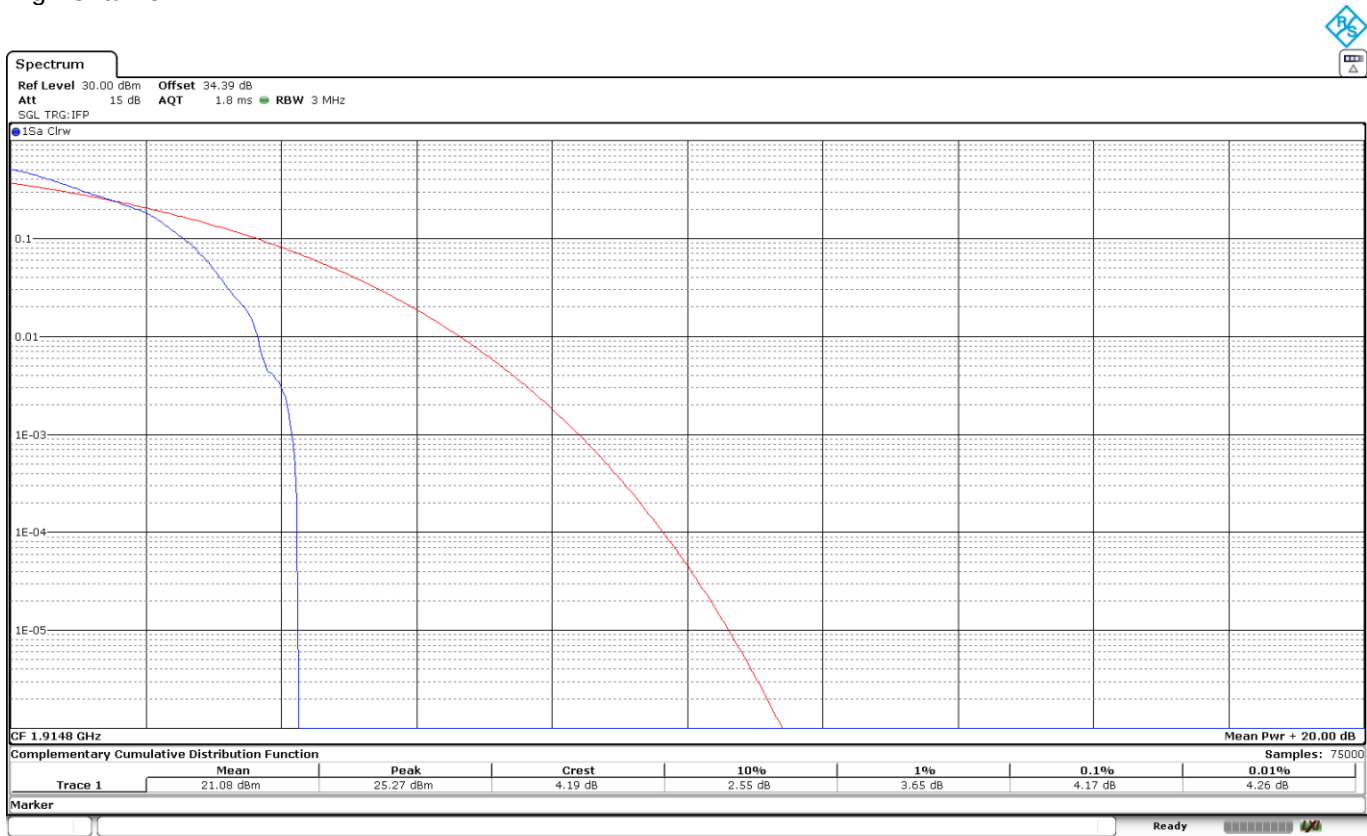


Middle Channel:



High Channel:



QPSK	Low	Middle	High
PAPR (dB)	4.29	4.03	4.17

Verdict

Pass

Frequency Stability

Limits

FCC §2.1055 and §24.235. The frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block.

RSS-133. Clause 6.3. The carrier frequency shall not depart from the reference frequency in excess of ± 2.5 ppm for mobile stations.

Method

The frequency tolerance measurements over temperature variations were made over the temperature range of -40°C to $+85^{\circ}\text{C}$. The EUT was placed inside a climatic chamber and the temperature was raised hourly in 10°C steps from -40°C up to $+85^{\circ}\text{C}$.

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" in 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.

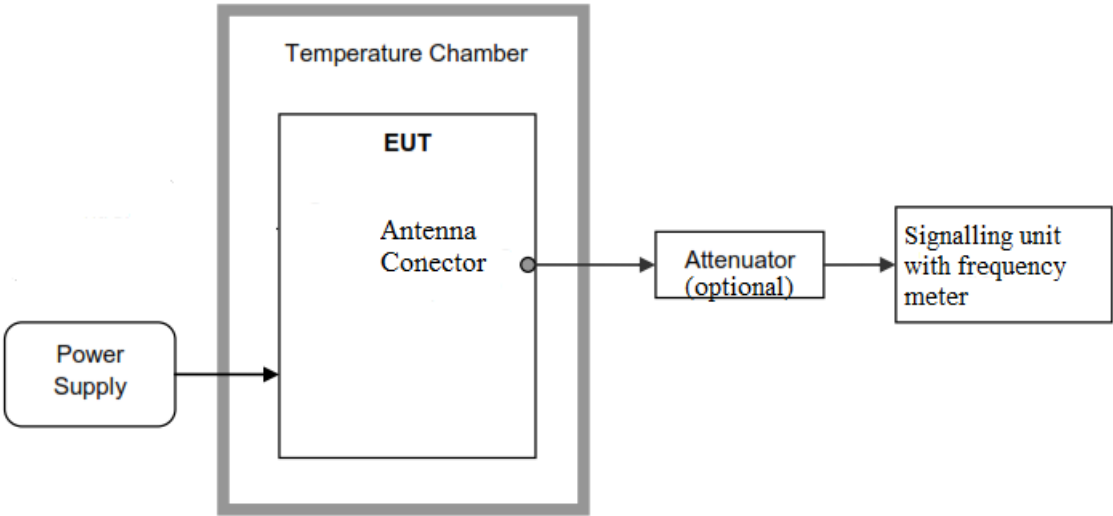
The worst case NB-IoT mode for conducted power was used for the test.

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

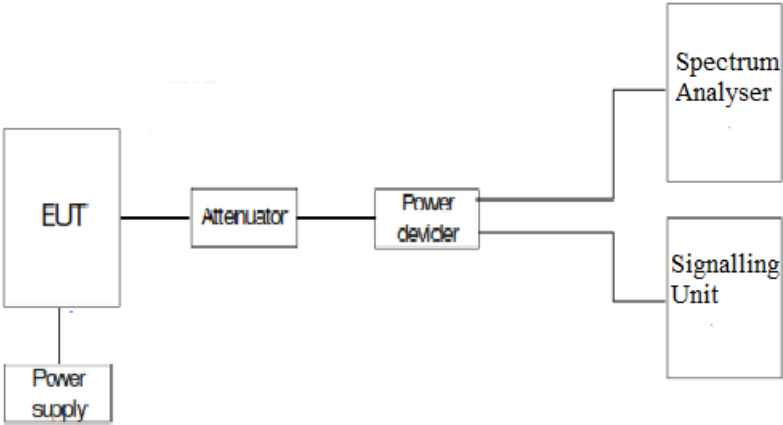
The reference point measurements were made at the RF output terminals of the EUT using an attenuator, power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

Test Setup

Frequency tolerance.



Reference points f_L and f_H .



Results

LTE Cat NB2 Band 25:

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

1. Frequency Tolerance:

- Frequency Stability over Temperature Variations:

Temperature (°C)	Frequency Error (Hz)	Frequency Error (ppm)
+85	15.92	0.008456839
+80	15.64	0.008308101
+70	11.9	0.006321381
+60	11.23	0.005965471
+50	10.59	0.005625498
+40	14.82	0.00787251
+30	1.85	0.000982736
+20	4.15	0.002204515
+10	0.54	0.000286853
0	3.76	0.001997344
-10	3.86	0.002050465
-20	2.86	0.001519256
-30	-6.15	-0.003266932
-40	23.9	0.012695883

- Frequency Stability over Voltage Variations.

Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	5.5	-8.48	-0.004504648
Vmin	3	-16.11	-0.008557769

2. Reference Frequency Points fL and fH:

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

fL (MHz)	1850.0225
fH (MHz)	1914.9757

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

Measurement uncertainty (Hz) <± 249.55

Verdict: PASS

Modulation Characteristics

Limits

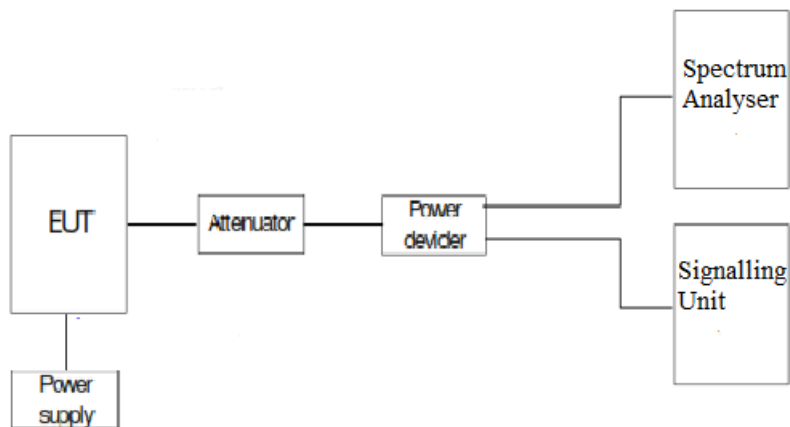
FCC §2.1047.

RSS-133. Clause 6.2. Equipment certified under this standard shall use digital modulation.

Method

For LTE NB2 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.

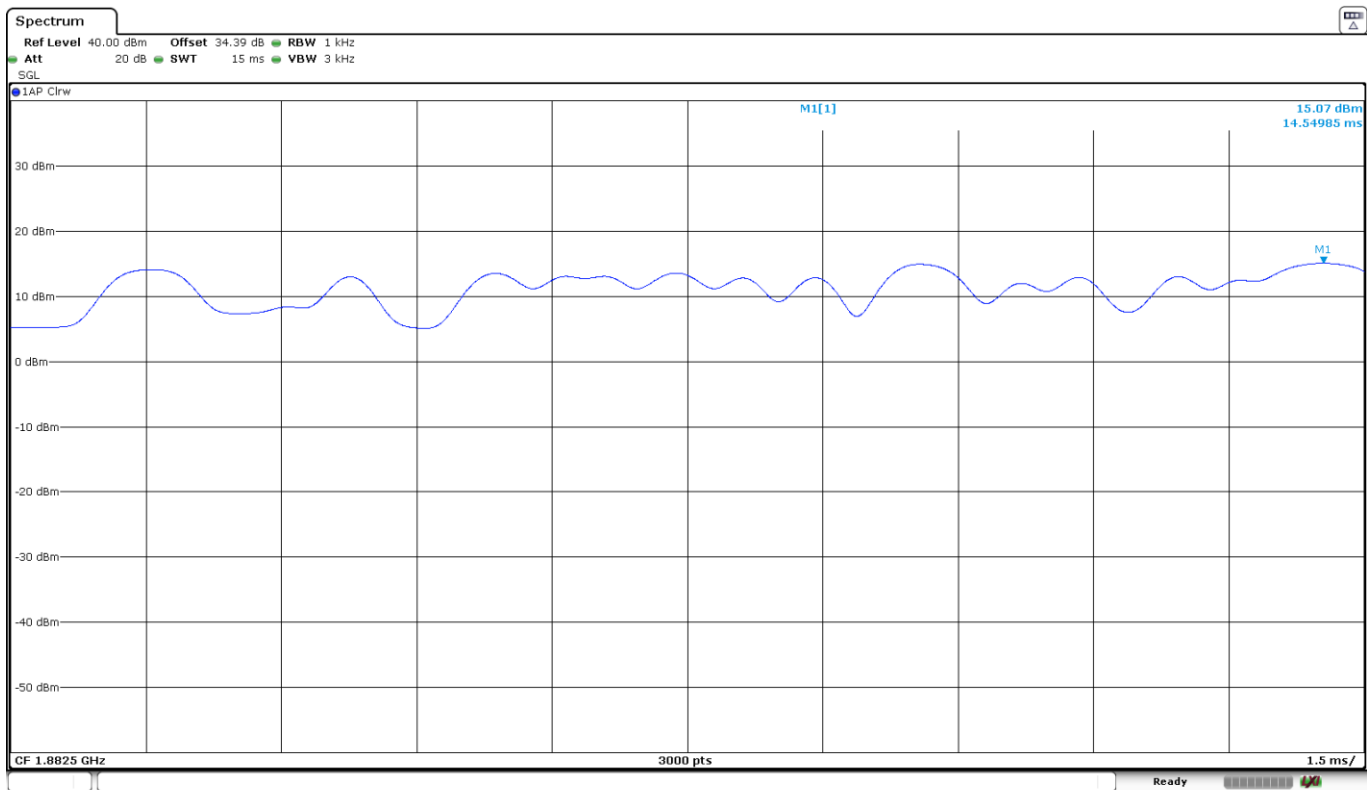
Test Setup



Results

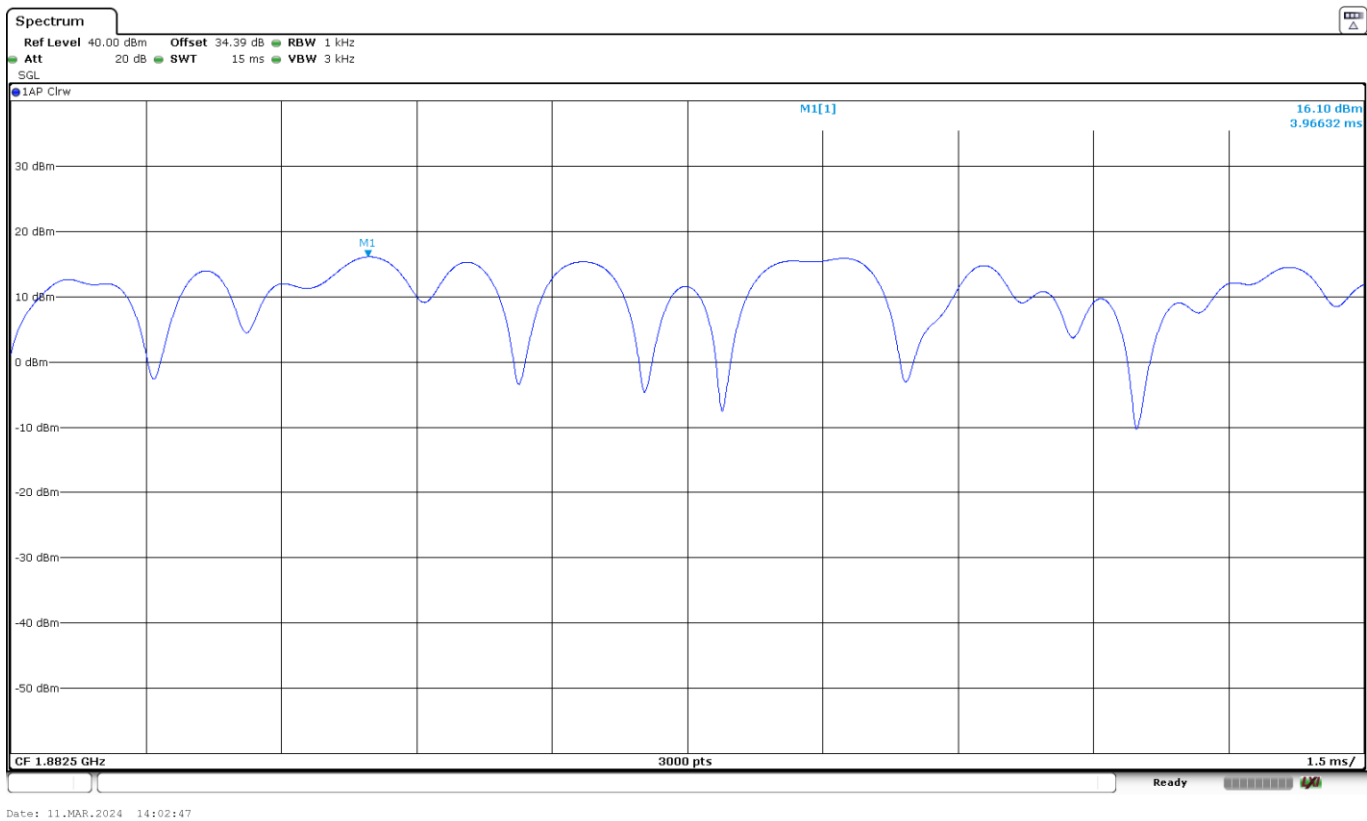
The following plot shows the modulation schemes in the EUT.

LTE Cat NB2 Band 25: Pi/2-BPSK. Middle Channel. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=0.

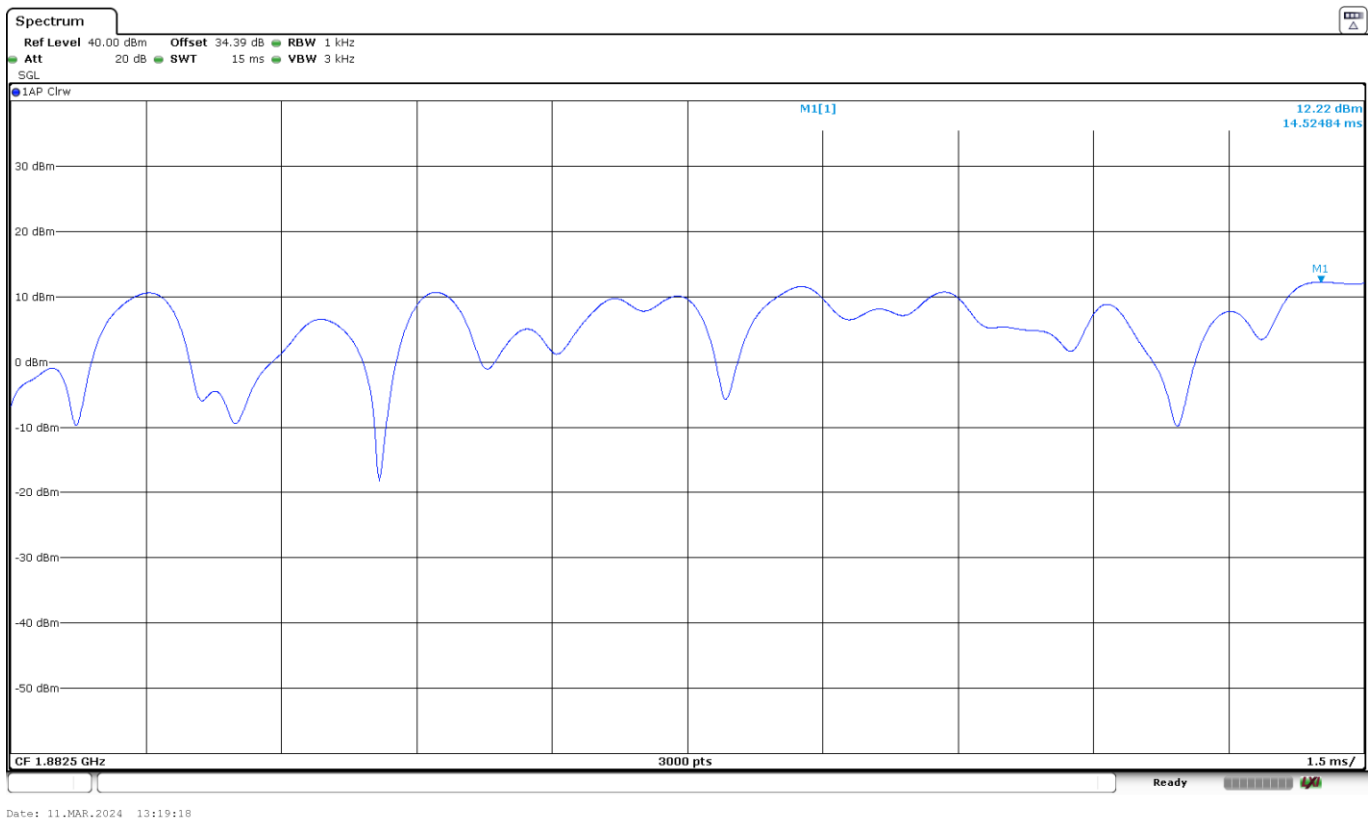


Date: 11.MAR.2024 14:02:29

LTE Cat NB2 Band 25: Pi/4-QPSK. Middle Channel. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=3.



LTE Cat NB2 Band 25: QPSK. Middle Channel. BW=15 kHz. Tone Number=3. Tone Offset=0. MSC/TBS=5.



Occupied Bandwidth

Limits

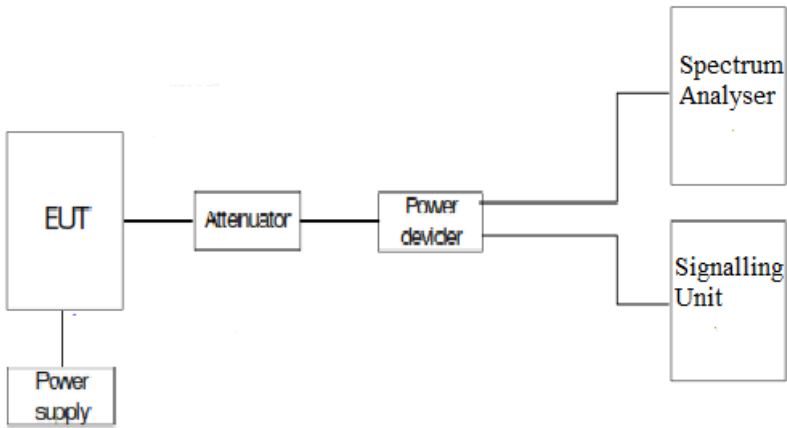
FCC §2.1049. Measurements required: Occupied bandwidth.

RSS-Gen, Clause 6.7.

Method

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

Test Setup



Results

The worst case per modulation is:

LTE Cat NB2 Band 25:

LTE Cat NB2 Band 25. Pi/2-BPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=23. MSC/TBS=0.

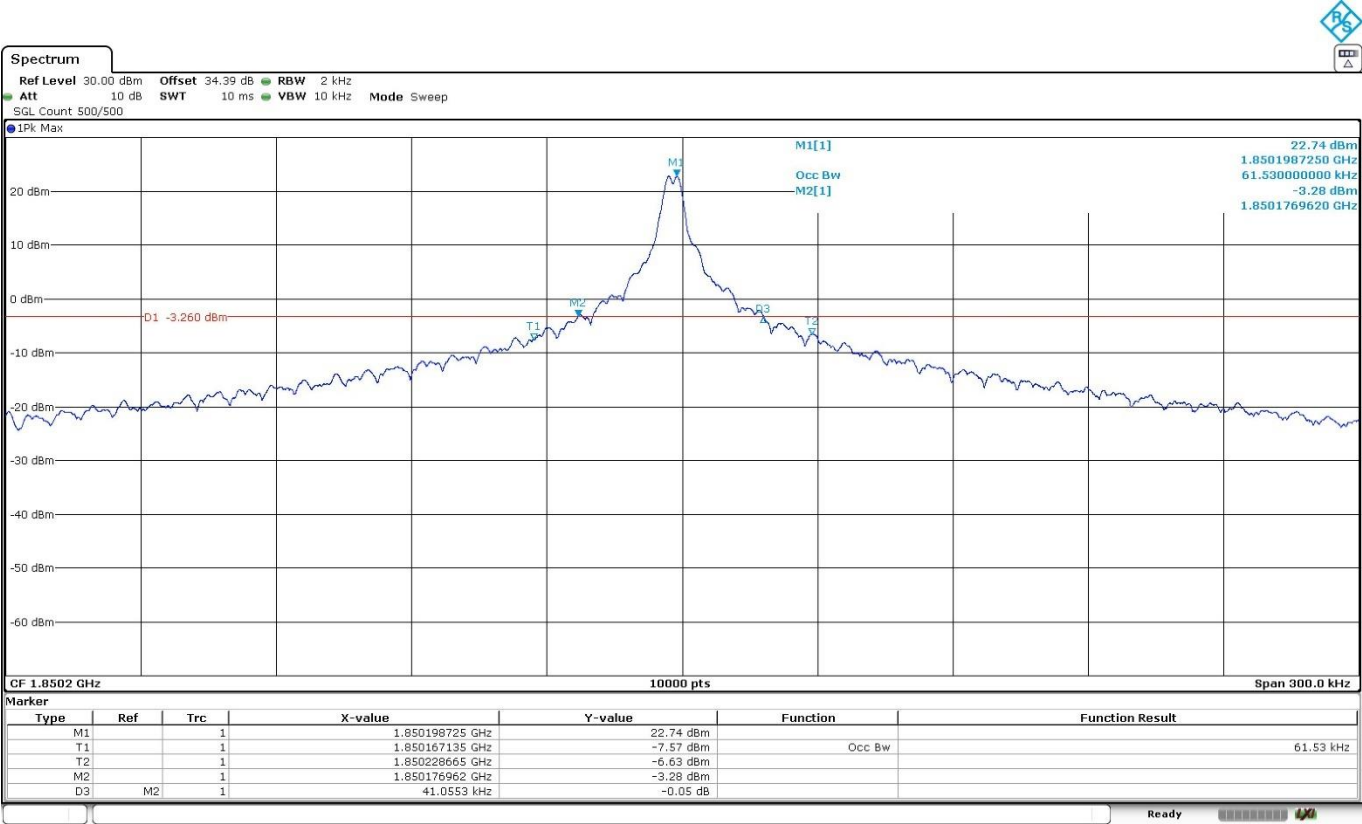
	Low Channel	Middle Channel	High Channel
99% Occupied Bandwidth (kHz)	61.53000	62.49000	61.44000
-26 dBc Bandwidth (kHz)	41.05530	41.14000	40.97020
Measurement uncertainty (kHz)	<±0.25		

LTE Cat NB2 Band 25. Pi/4-QPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=23. MSC/TBS=3.

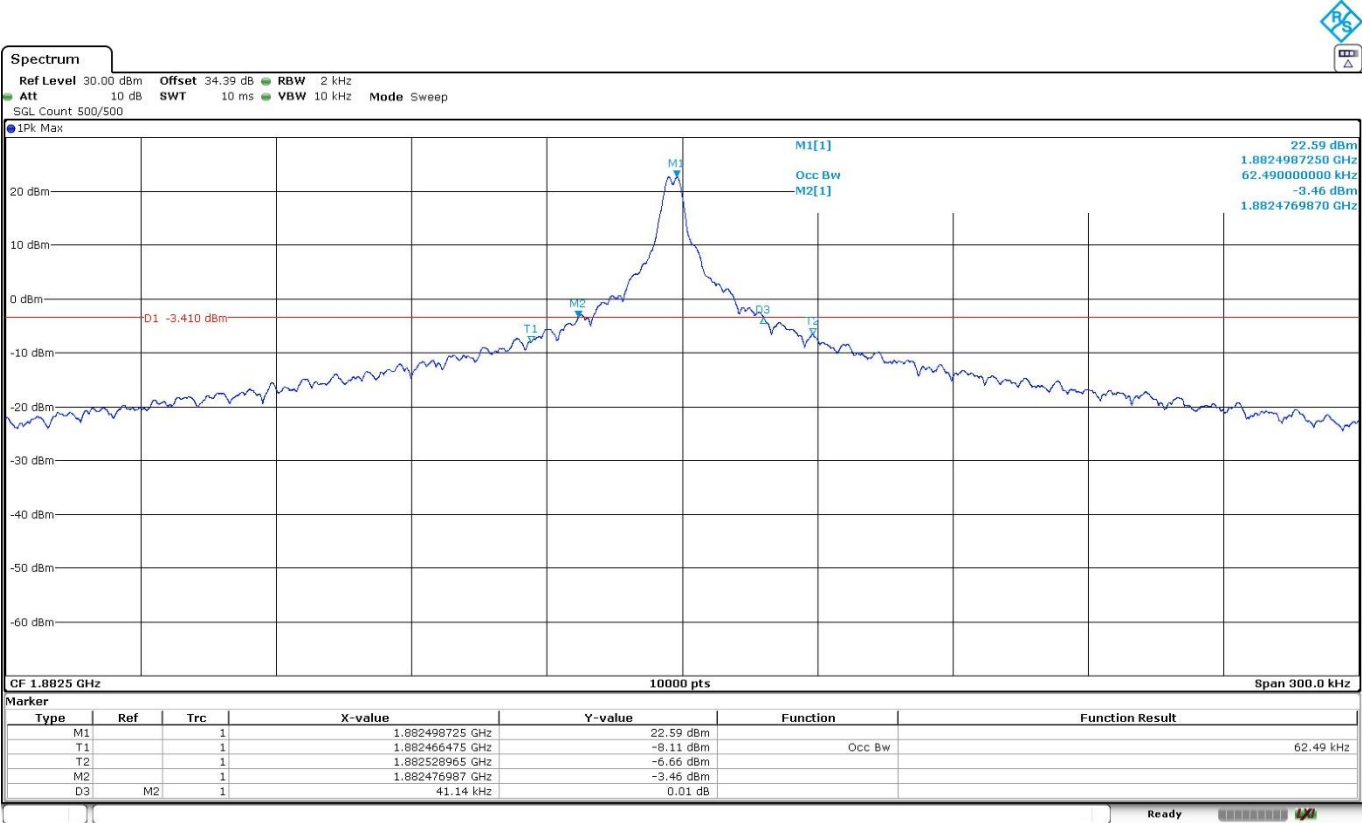
	Low Channel	Middle Channel	High Channel
99% Occupied Bandwidth (kHz)	65.61000	66.84000	66.60000
-26 dBc Bandwidth (kHz)	41.90000	41.80000	41.81630
Measurement uncertainty (kHz)	<±0.25		

LTE Cat NB2 Band 25. Pi/2-BPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=23. MSC/TBS=0.

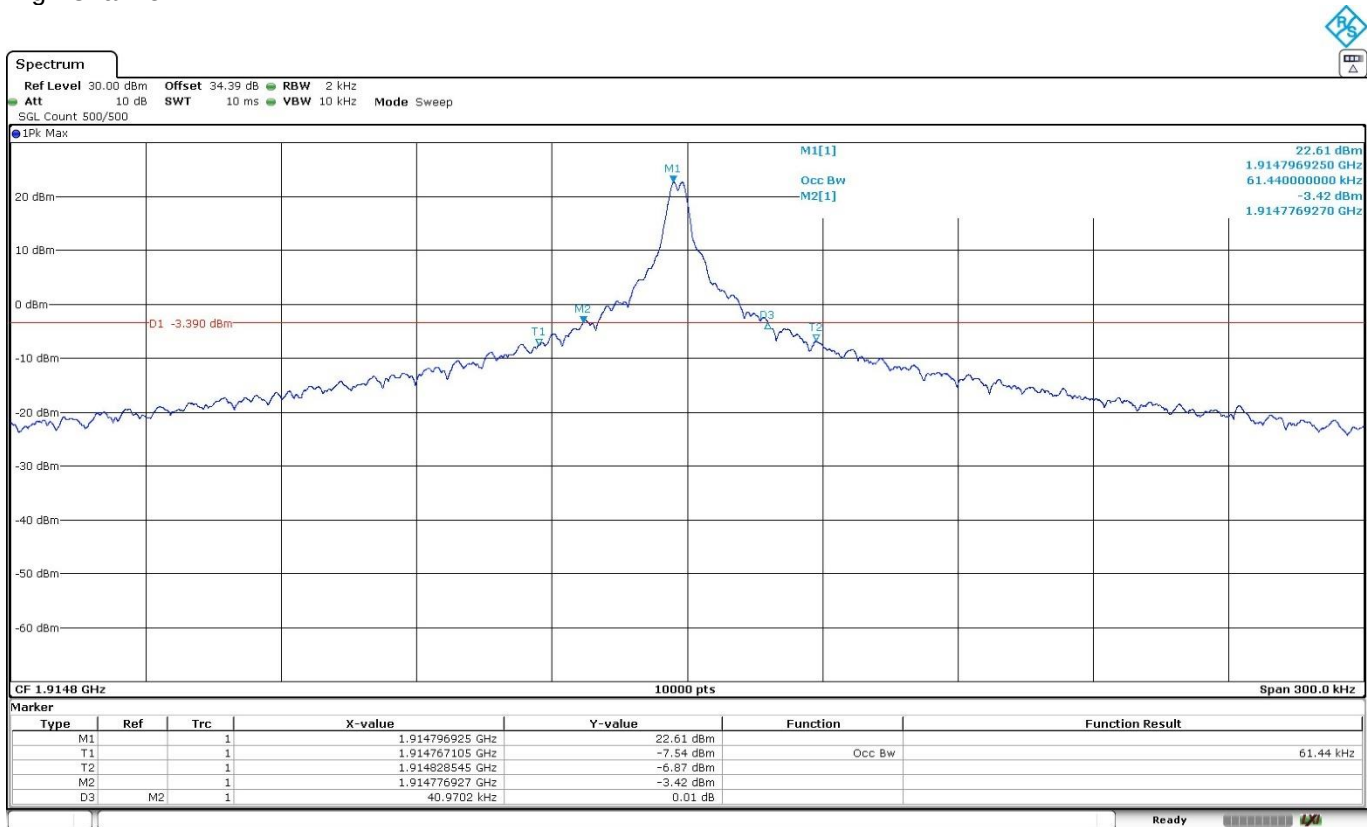
Low Channel:



Middle Channel:

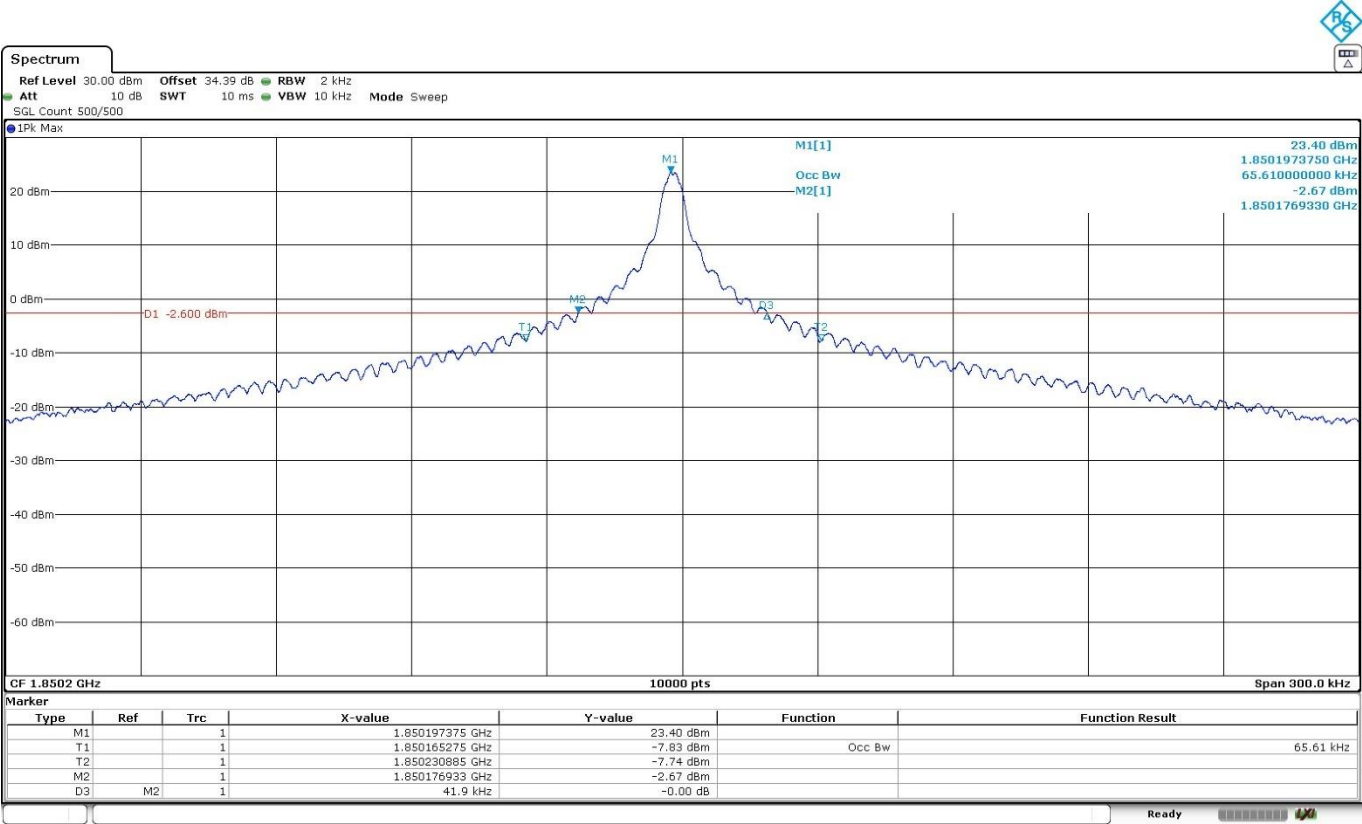


High Channel:

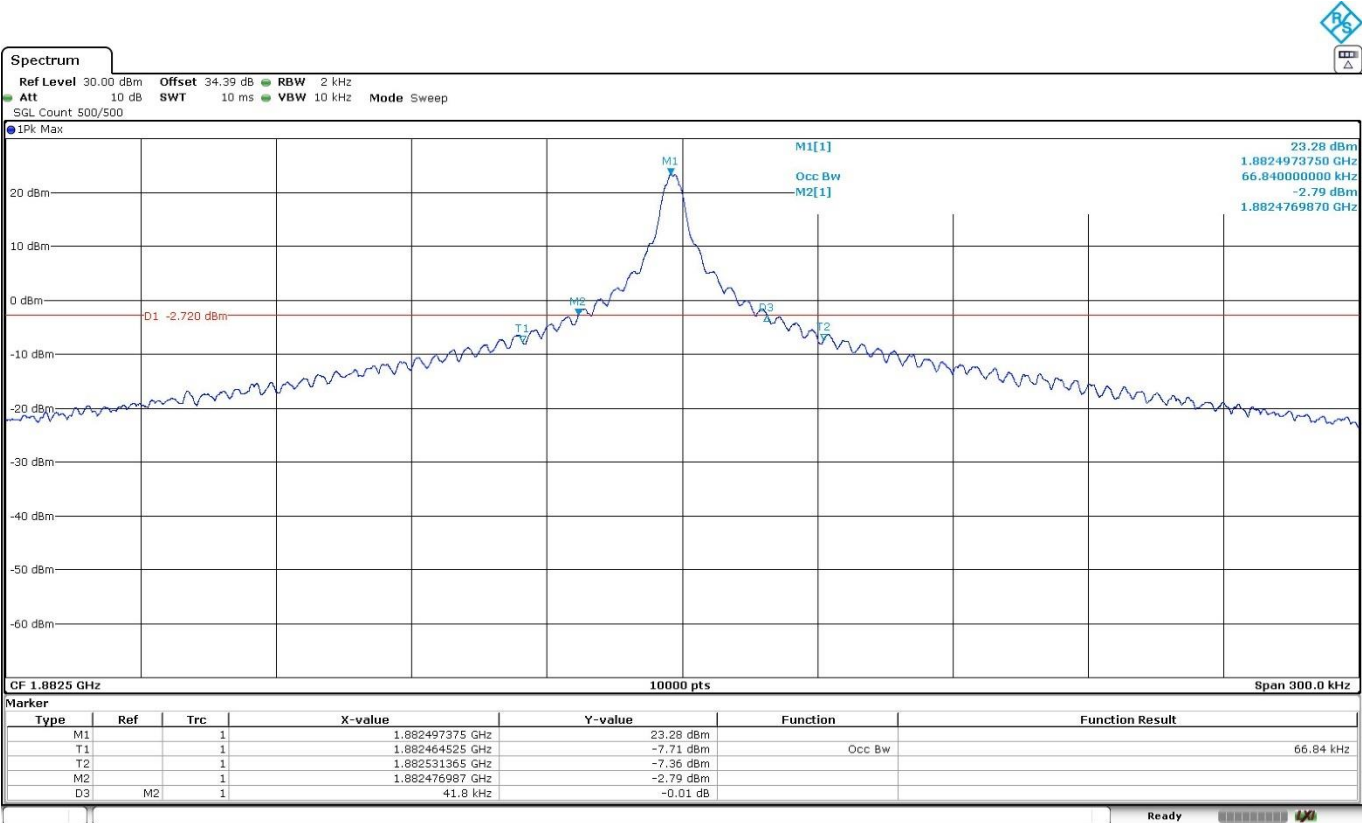


LTE Cat NB2 Band 25. Pi/4-QPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=23. MSC/TBS=3.

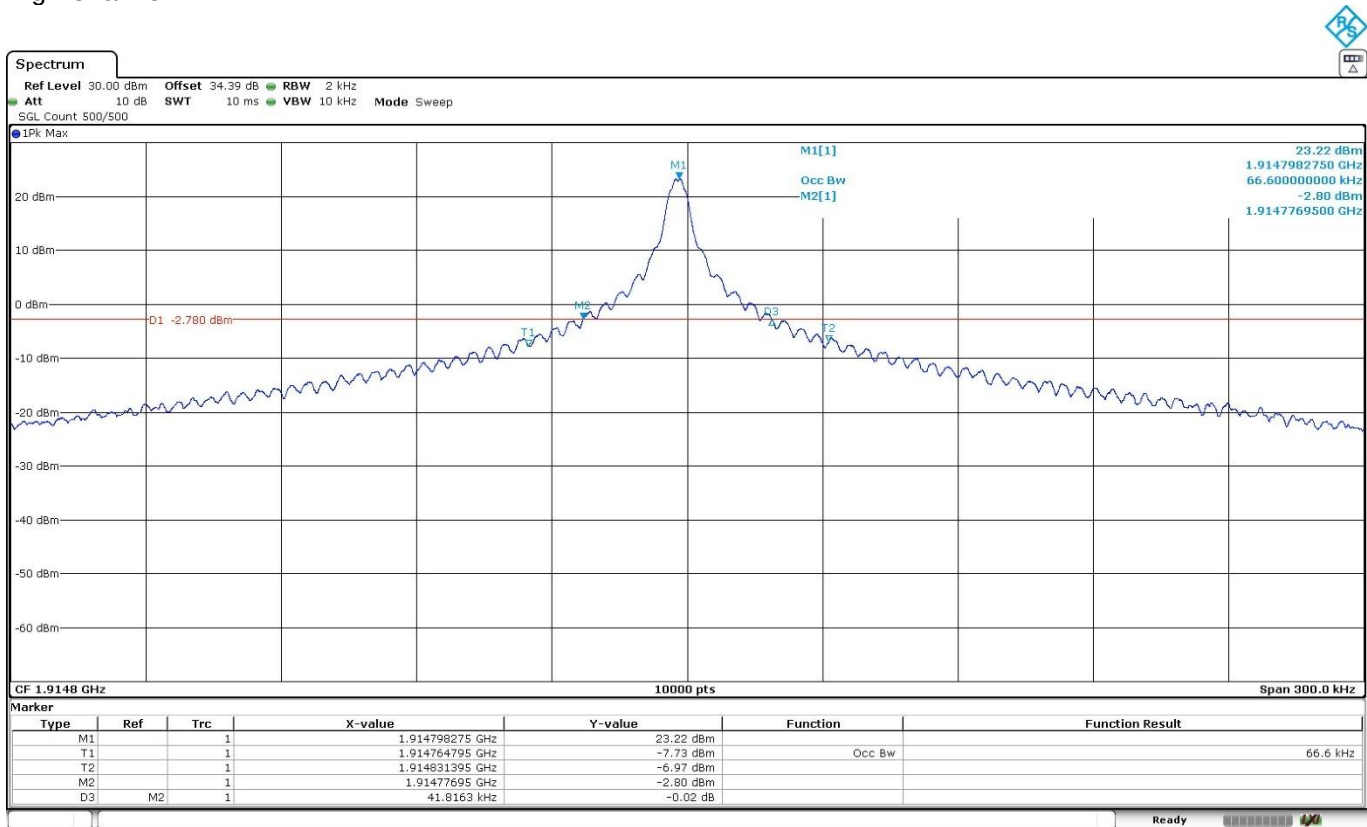
Low Channel:



Middle Channel:



High Channel:



LTE Cat NB2 Band 25. Pi/2-BPSK. BW=15 kHz. Tone Number=1. Tone Offset=5. MSC/TBS=0.

	Low Channel	Middle Channel	High Channel
99% Occupied Bandwidth (kHz)	127.71000	126.90000	125.49000
-26 dBc Bandwidth (kHz)	133.34790	130.55900	113.29420
Measurement uncertainty (kHz)	<±0.25		

LTE Cat NB2 Band 25. Pi/4-QPSK. BW=15 kHz. Tone Number=1. Tone Offset=5. MSC/TBS=3.

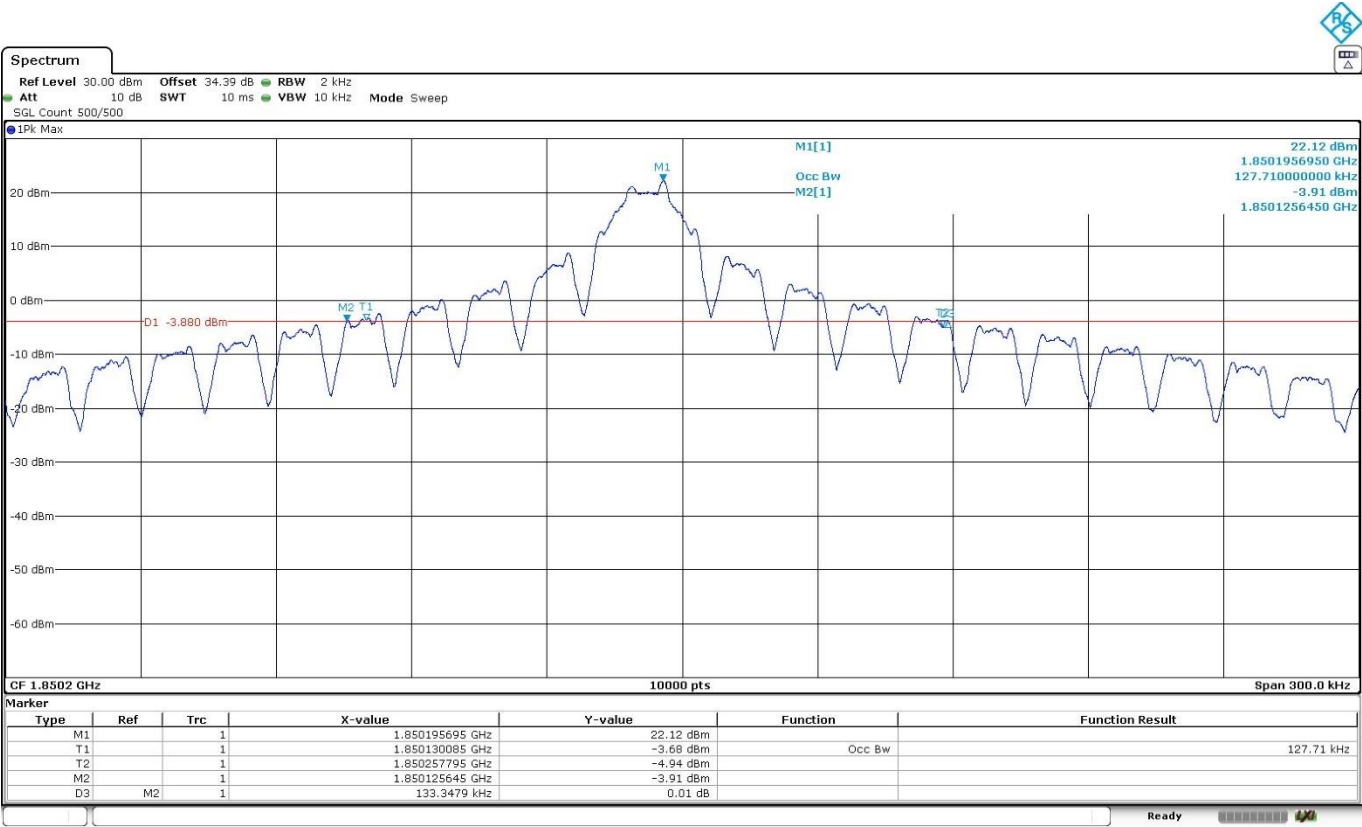
	Low Channel	Middle Channel	High Channel
99% Occupied Bandwidth (kHz)	127.56000	126.39000	126.60000
-26 dBc Bandwidth (kHz)	131.72790	154.23100	158.47140
Measurement uncertainty (kHz)	<±0.25		

LTE Cat NB2 Band 25. QPSK. BW=15 kHz. Tone Number=12. Tone Offset=0. MSC/TBS=5.

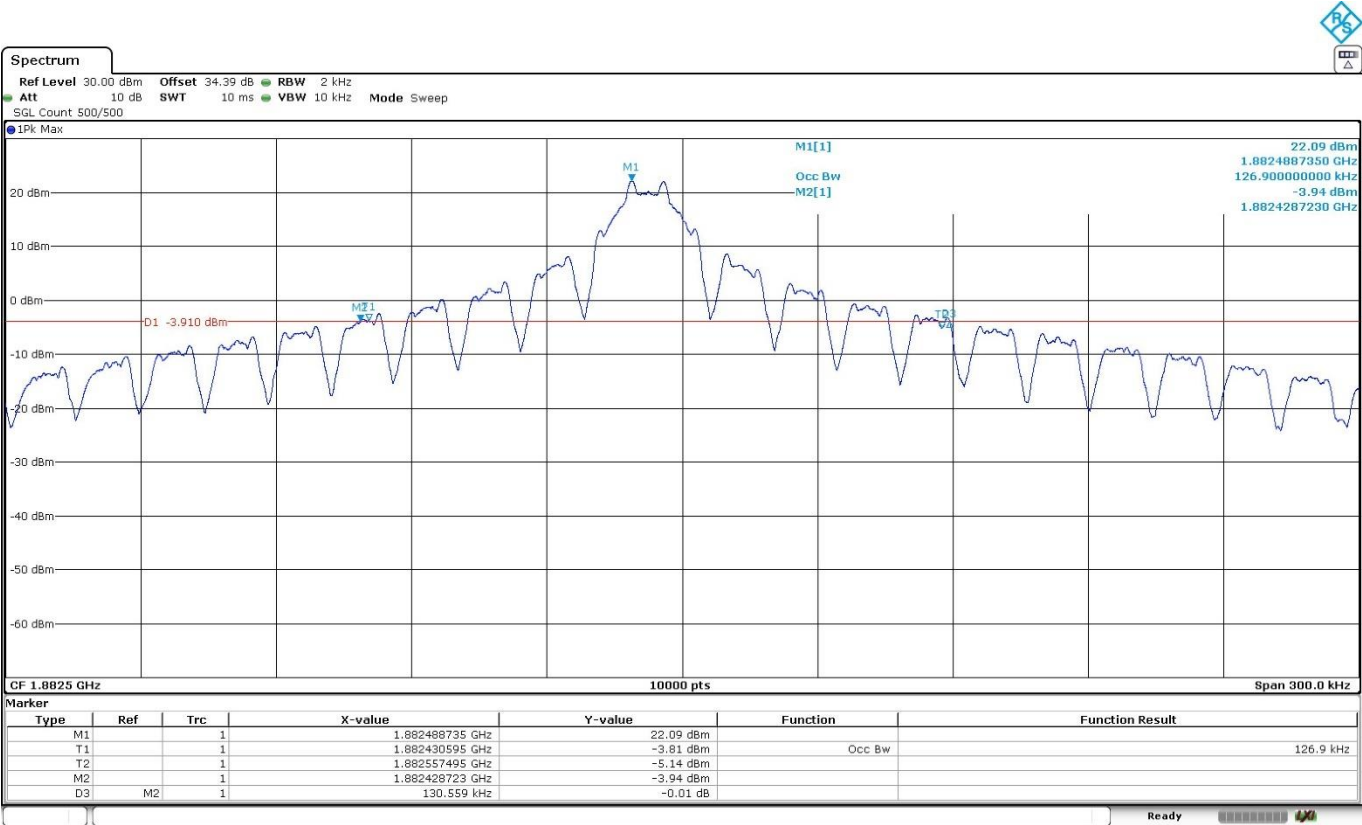
	Low Channel	Middle Channel	High Channel
99% Occupied Bandwidth (kHz)	188.40000	187.90000	188.50000
-26 dBc Bandwidth (kHz)	312.45900	302.56410	321.29000
Measurement uncertainty (kHz)	<±0.25		

LTE Cat NB2 Band 25. Pi/2-BPSK. BW=15 kHz. Tone Number=1. Tone Offset=5. MSC/TBS=0.

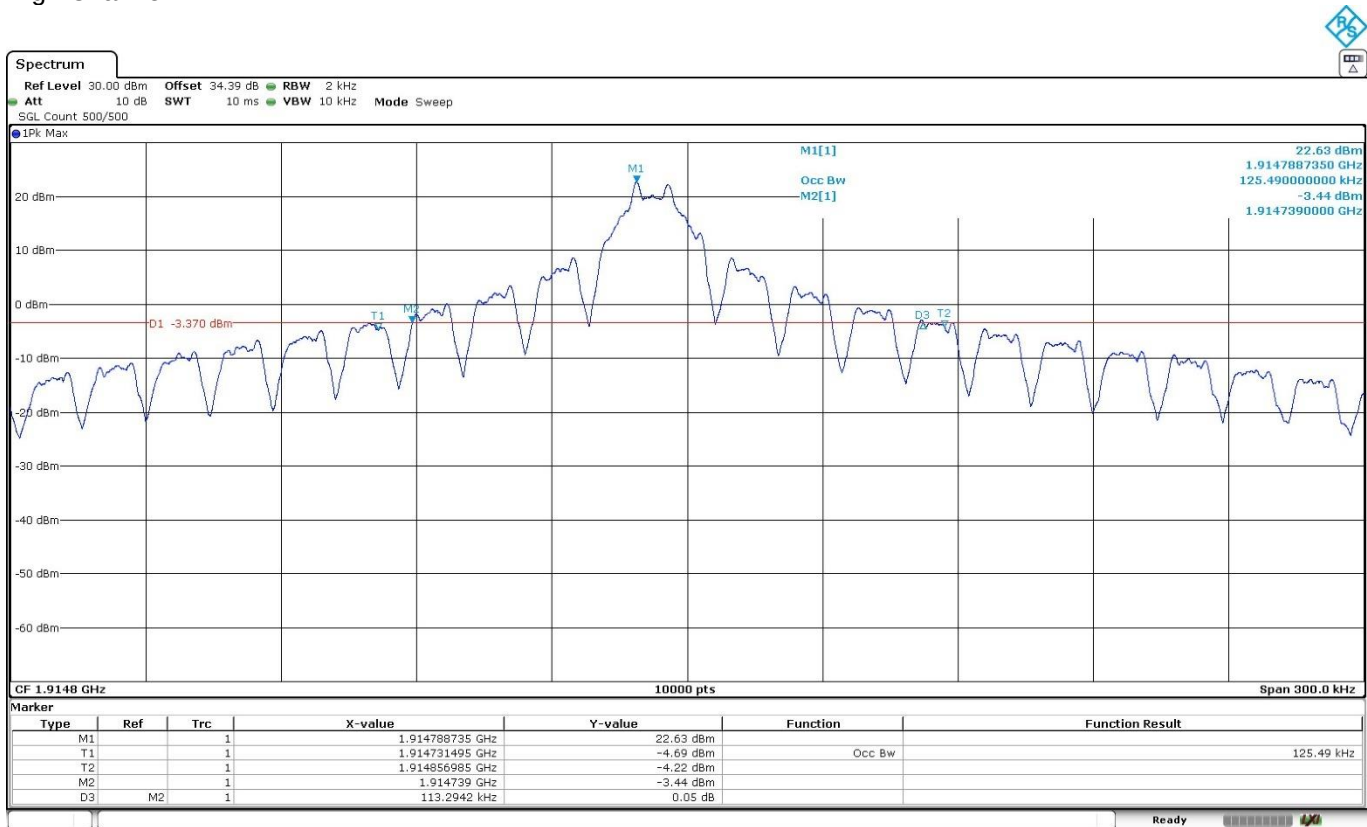
Low Channel:



Middle Channel:

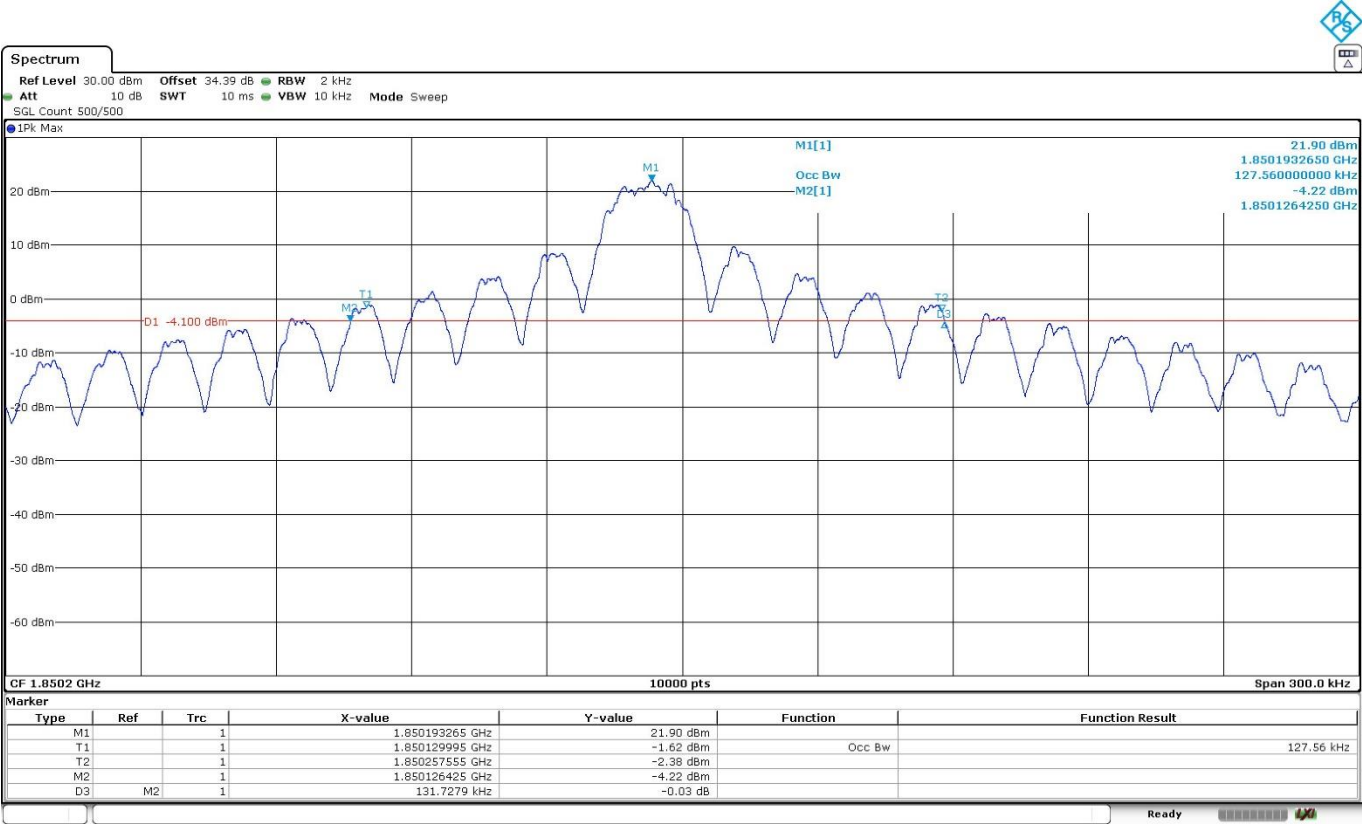


High Channel:

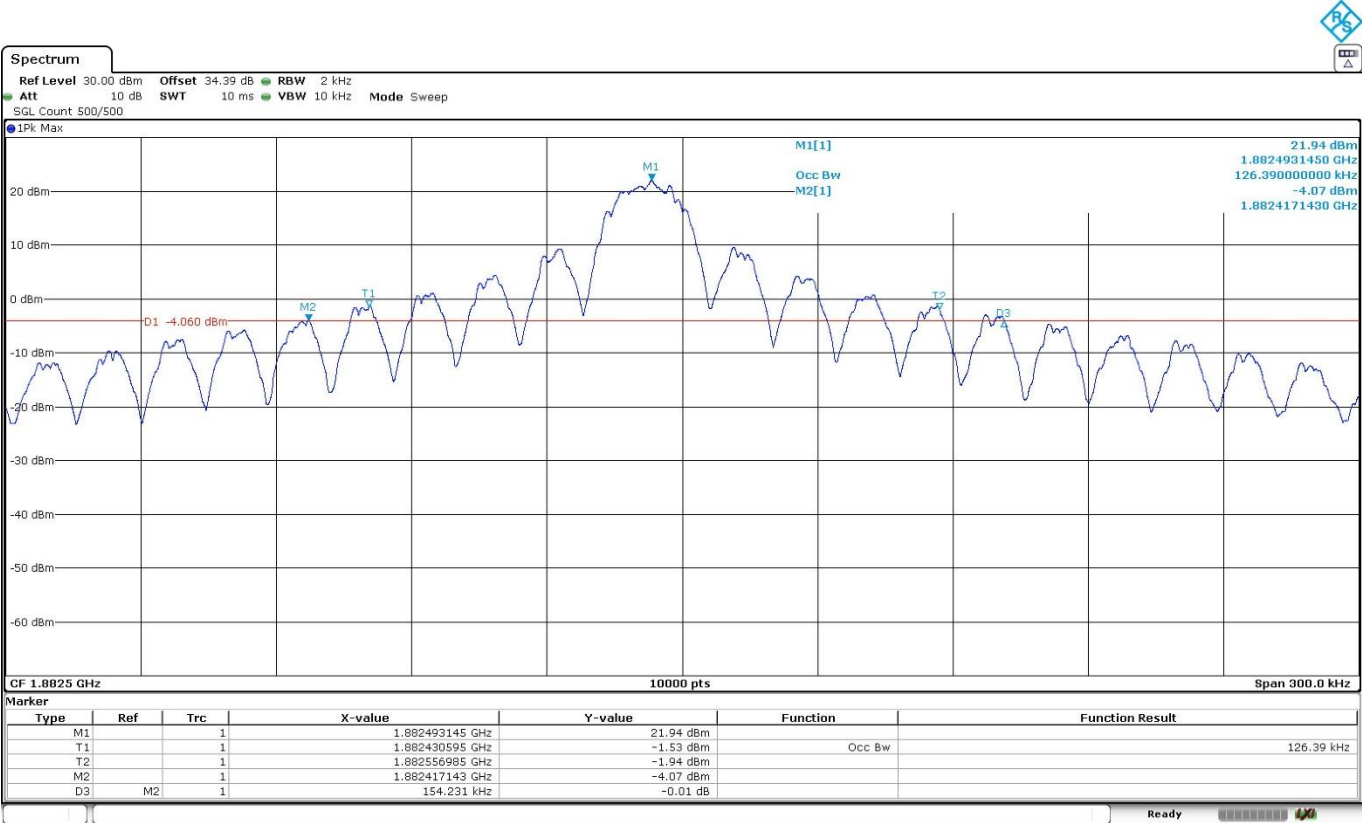


LTE Cat NB2 Band 25. Pi/4-QPSK. BW=15 kHz. Tone Number=1. Tone Offset=5. MSC/TBS=3.

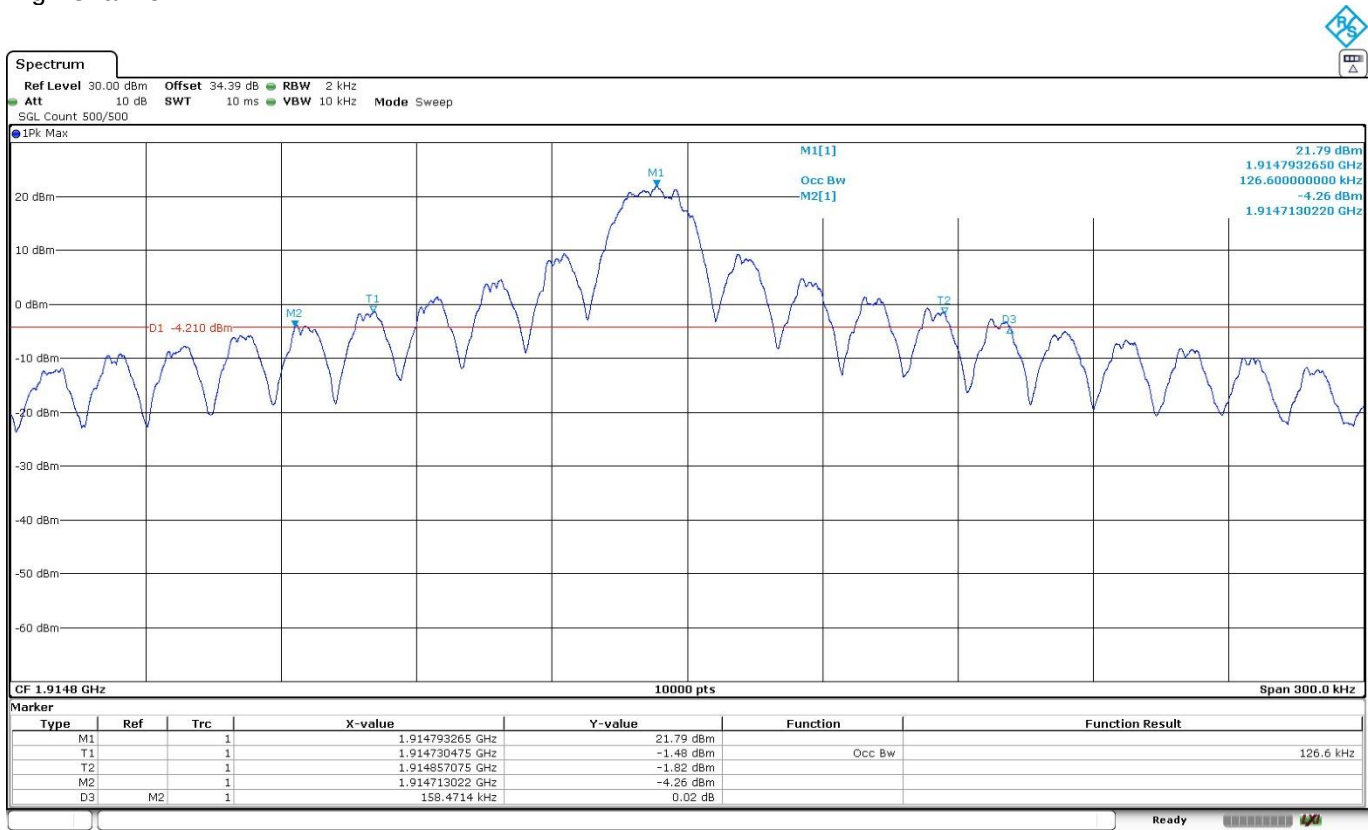
Low Channel:



Middle Channel:

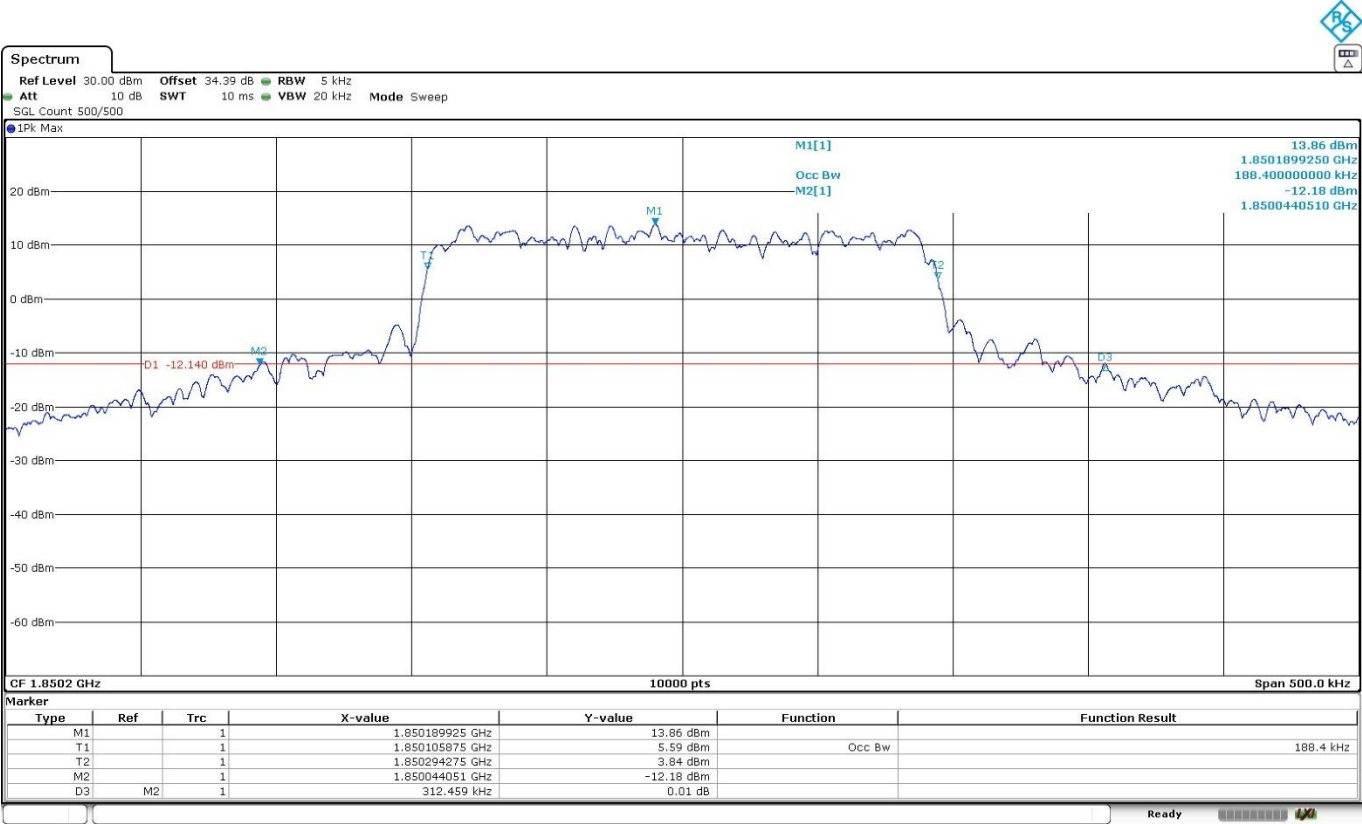


High Channel:

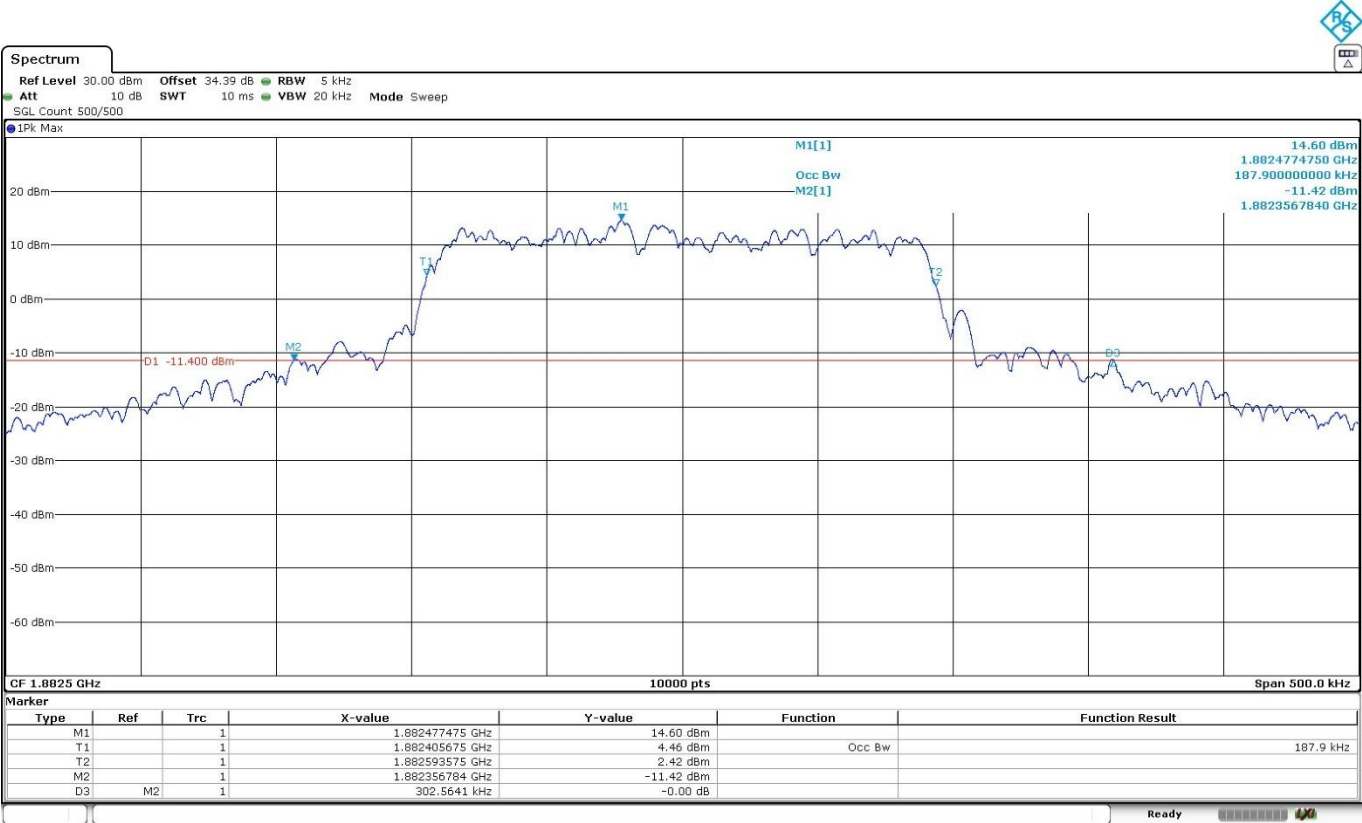


LTE Cat NB2 Band 25. QPSK. BW=15 kHz. Tone Number=12. Tone Offset=0. MSC/TBS=5.

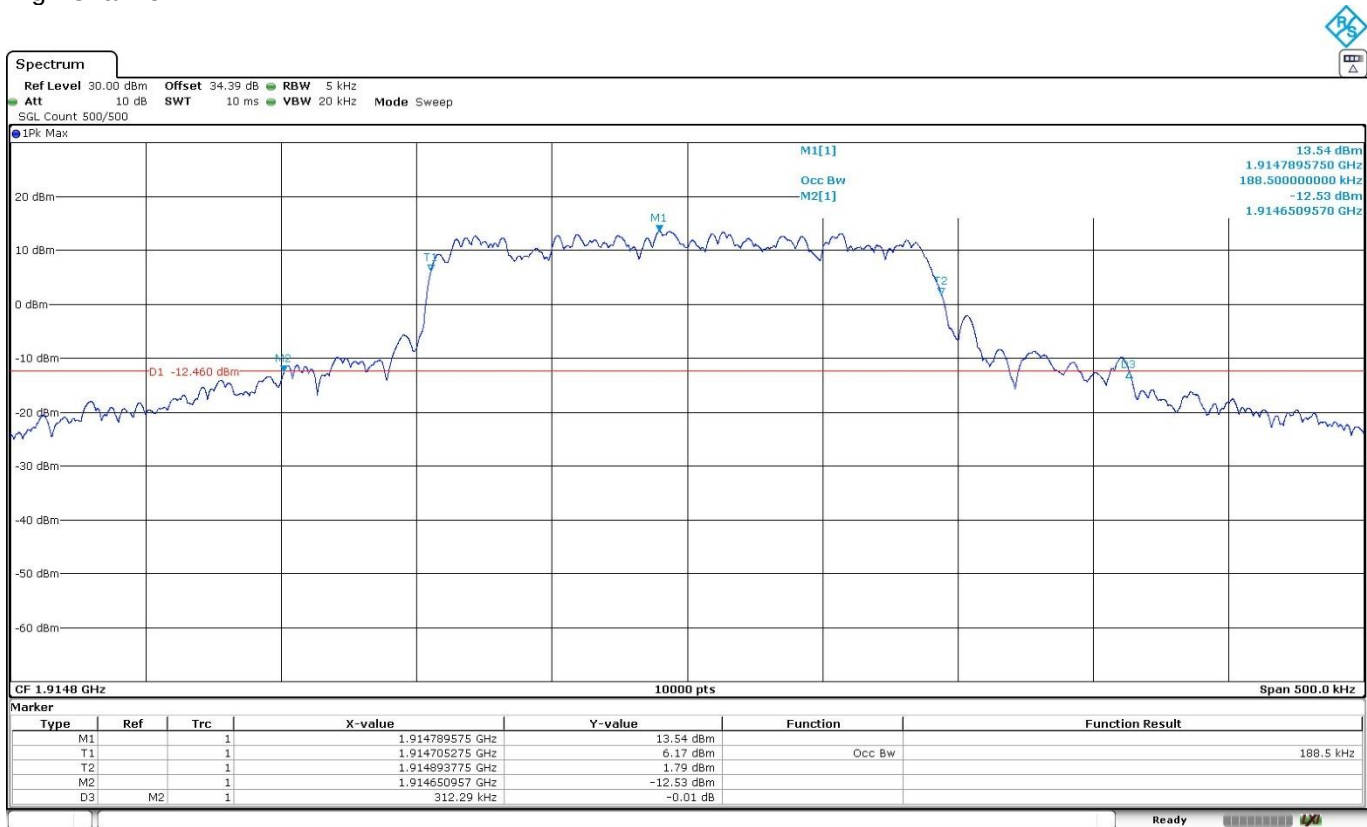
Low Channel:



Middle Channel:



High Channel:



Spurious emissions at antenna terminals

Limits

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

The power of emissions shall be attenuated below the transmitter power (P) by a factor of at least $43 + 10 \log (P)$ dB. P in watts.

At P_o transmitting power, the specified minimum attenuation becomes $43+10 \log (P_o)$, and the level in dBm relative P_o becomes:

$P_o \text{ (dBm)} - [43 + 10 \log (P_o \text{ in mwatts}) - 30] = -13 \text{ dBm}$.

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 20 GHz for NB-IoT Band 25.

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.

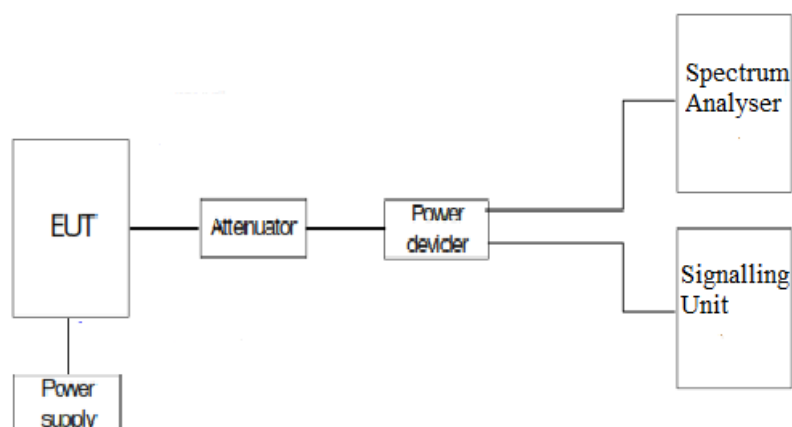
Measurement Limit:

According to specification, the power of emissions shall be attenuated below the transmitter power (P) by a factor of at least $43 + 10 \log (P)$ dB. P in watts.

At P_o transmitting power, the specified minimum attenuation becomes $43+10 \log (P_o)$, and the level in dBm relative P_o becomes:

$$P_o \text{ (dBm)} - [43 + 10 \log (P_o \text{ in mwatts}) - 30] = -13 \text{ dBm}$$

Test Setup



Results

LTE Cat NB2 Band 25:

A preliminary scan determined the worst-case:

Pi/2-BPSK. BW=15 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=0.

The next results are for this worst-case configuration.

Frequency range 9 KHz - 20 GHz:

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

Measurement uncertainty (dB): $<\pm 2.76$

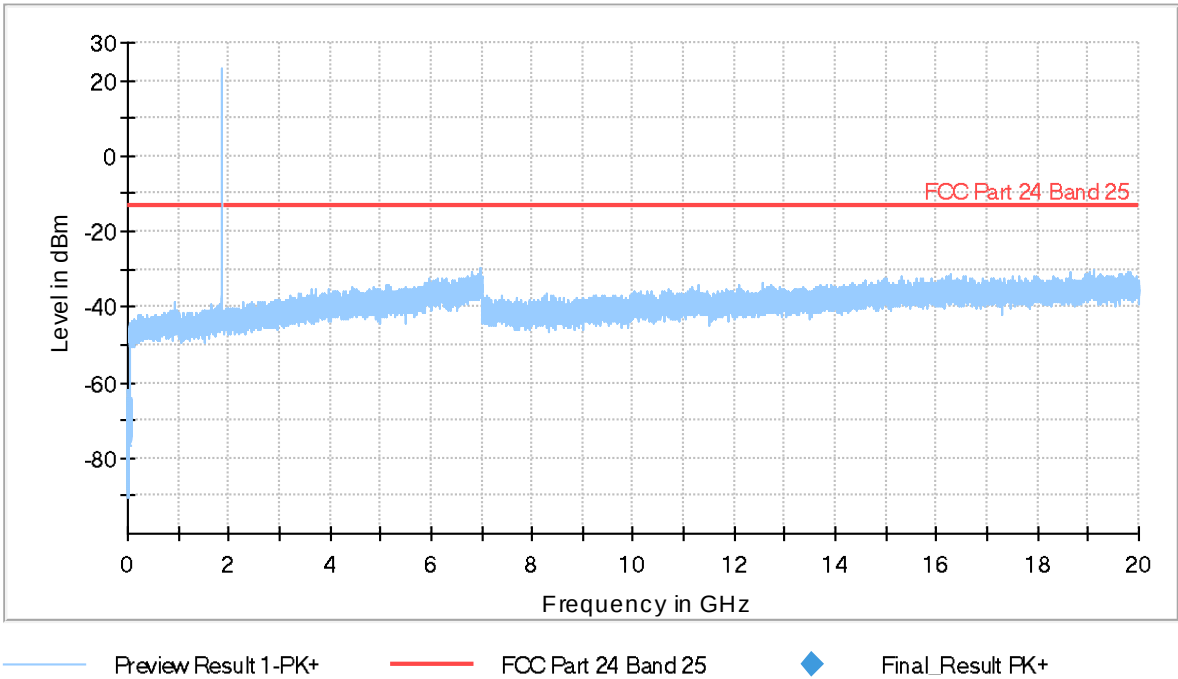
Verdict: PASS

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
9 kHz - 150 kHz	14.1 Hz	PK+	300 Hz	Coupled	0 dB
150 kHz - 30 MHz	932.812 Hz	PK+	10 kHz	Coupled	0 dB
30 MHz - 1 GHz	303.125 kHz	PK+	1 MHz	Coupled	0 dB
1 GHz - 10 GHz	281.25 kHz	PK+	1 MHz	Coupled	0 dB
10 GHz - 20 GHz	312.5 kHz	PK+	1 MHz	Coupled	0 dB

LTE Cat-NB2 Band 25: Pi/2-BPSK. BW=15 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=0.

Low Channel:

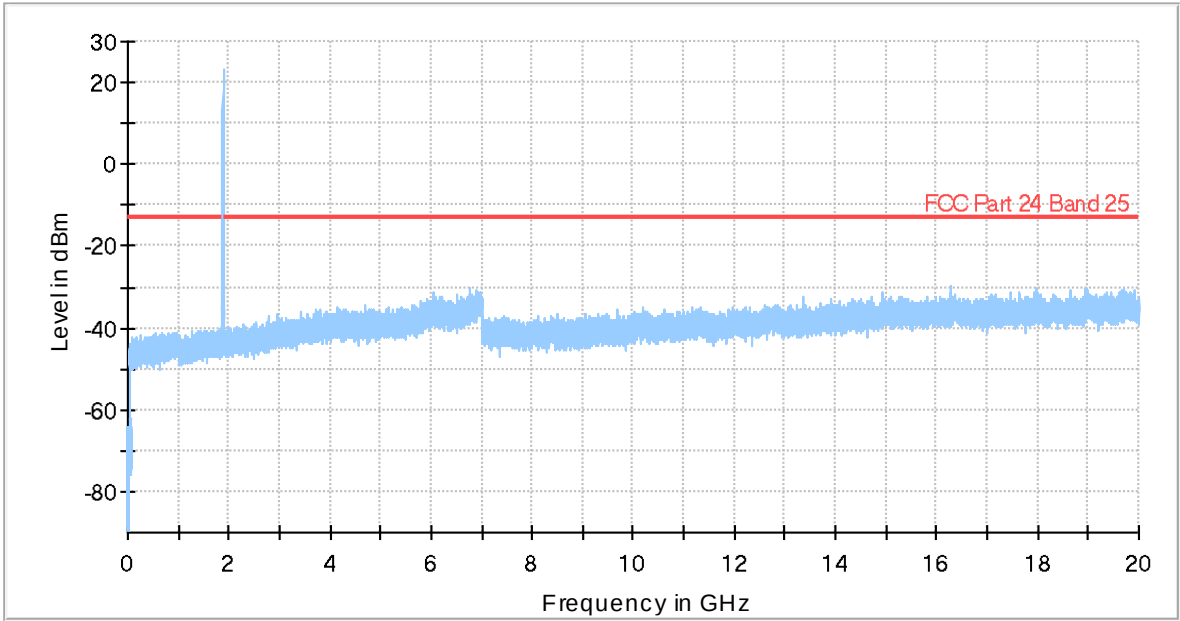
Full Spectrum



The peak above the limit is the carrier frequency.

Middle Channel:

Full Spectrum

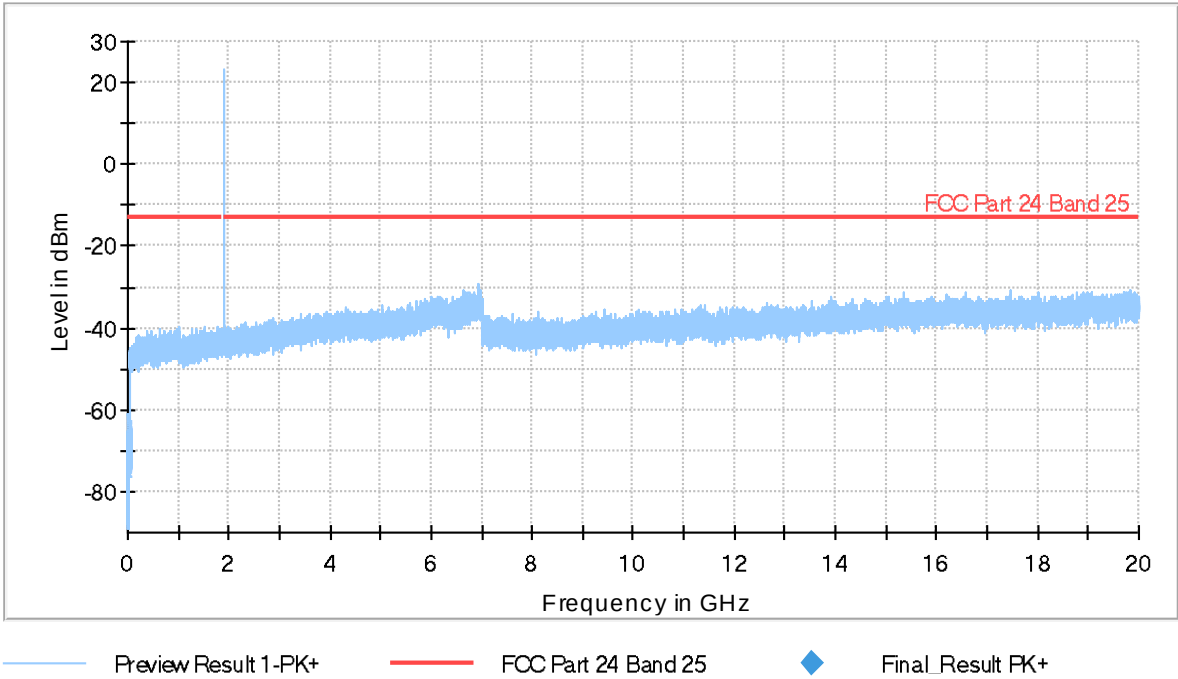


Preview Result 1-PK+ FCC Part 24 Band 25 Final Result PK+

The peak above the limit is the carrier frequency.

High Channel:

Full Spectrum



The peak above the limit is the carrier frequency.

Spurious emissions at antenna terminals at Block Edges

Limits

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

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

At P_o transmitting power, the specified minimum attenuation becomes $43 + 10 \log(P_o)$, and the level in dBm relative to P_o becomes:

$$P_o \text{ (dBm)} - [43 + 10 \log(P_o \text{ in mW}) - 30] = -13 \text{ dBm}$$

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.

As indicated in FCC part 24. 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/occupied bandwidth of the fundamental emission of the transmitter may be employed.

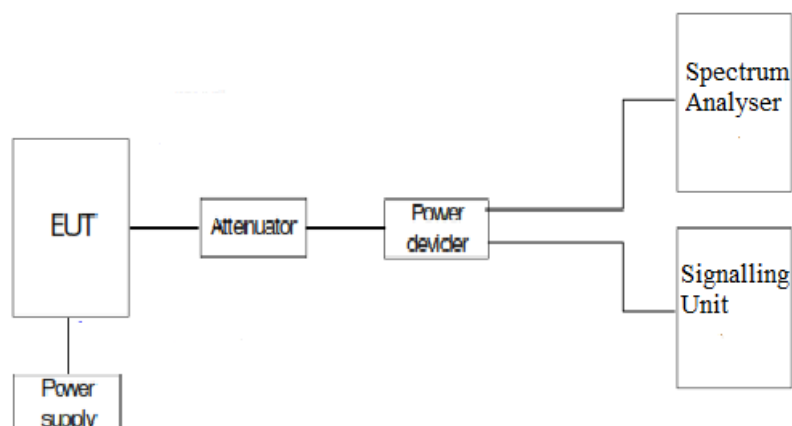
Measurement Limit:

According to specification. the power of emissions shall be attenuated below the transmitter power (P) by a factor of at least $43 + 10 \log(P)$ dB. P in watts.

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

$$P_o \text{ (dBm)} - [43 + 10 \log(P_o \text{ in mwatts}) - 30] = -13 \text{ dBm}$$

Test Setup



Results

LTE Cat NB2 Band 2:

Preliminary measurements determined the worst-case. Results attached are for this worst-case configuration.

Low Block Edge.

Note: Low Block Edge for LTE Cat NB2 Band 2 is the same as for LTE Cat NB2 Band 25.

High Block Edge.

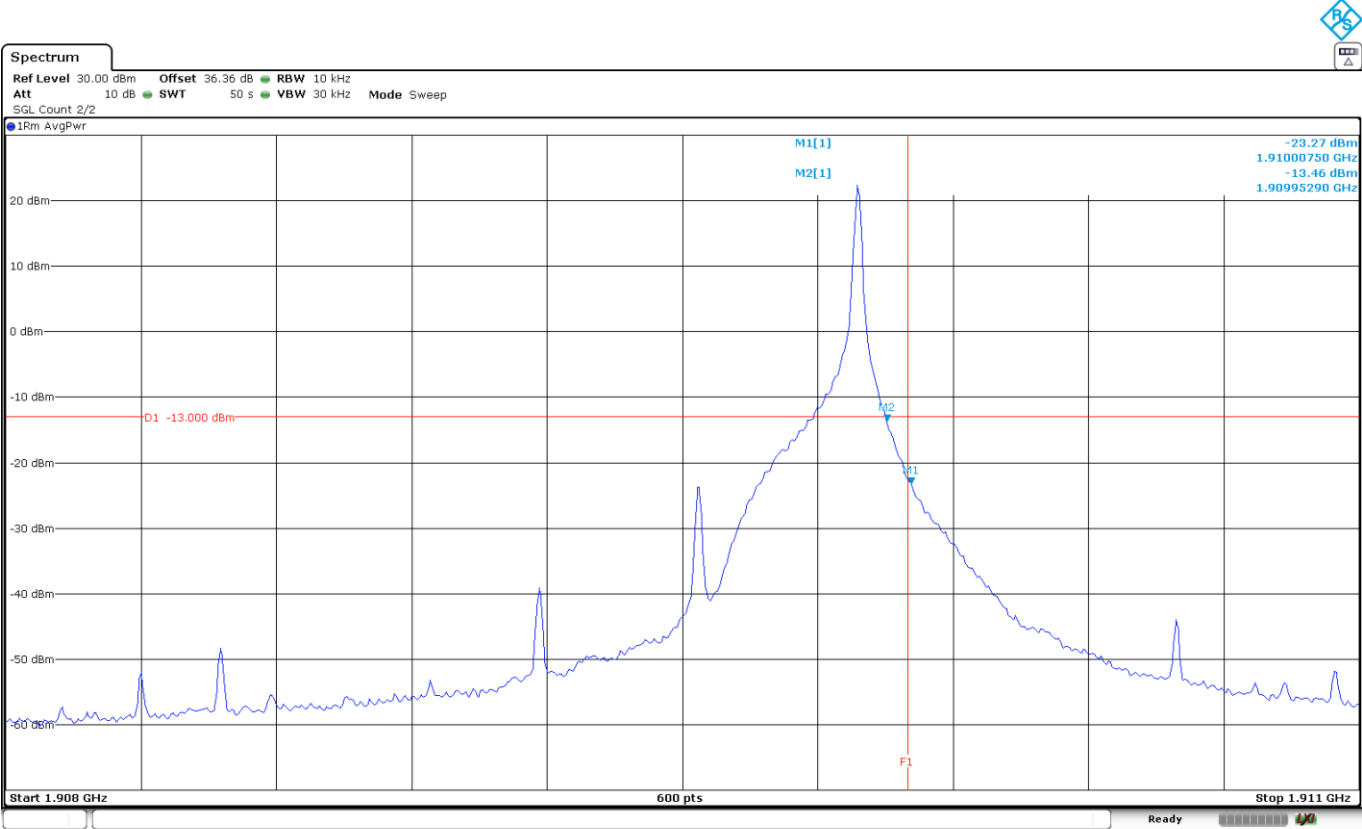
LTE Cat NB2 Band 2	Pi/2-BPSK BW=3.75 kHz Tone Number=1 Tone Offset=47 MSC/TBS=0	Pi/2-BPSK BW=15 kHz Tone Number=1 Tone Offset=11 MSC/TBS=0	QPSK BW=15 kHz Tone Number=12 Tone Offset=0 MSC/TBS=5
Maximum measured level at <u>High Block Edge</u> at antenna port (dBm)	-23.27	-22.88	-22.57

Measurement uncertainty (dB): <±2.76

Verdict

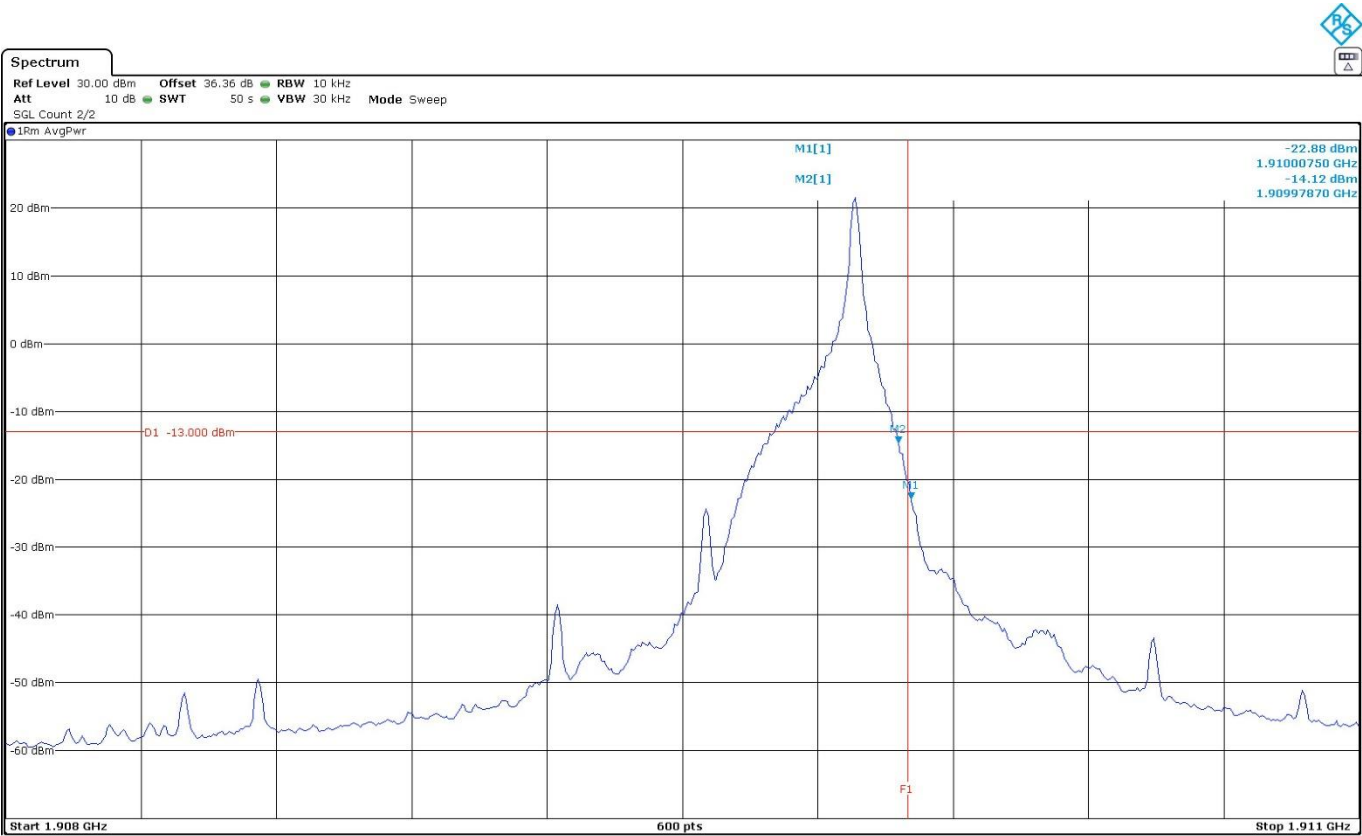
Pass

LTE Cat NB2 Band 2. Pi/2-BPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=47. MSC/TBS=0. High Channel:



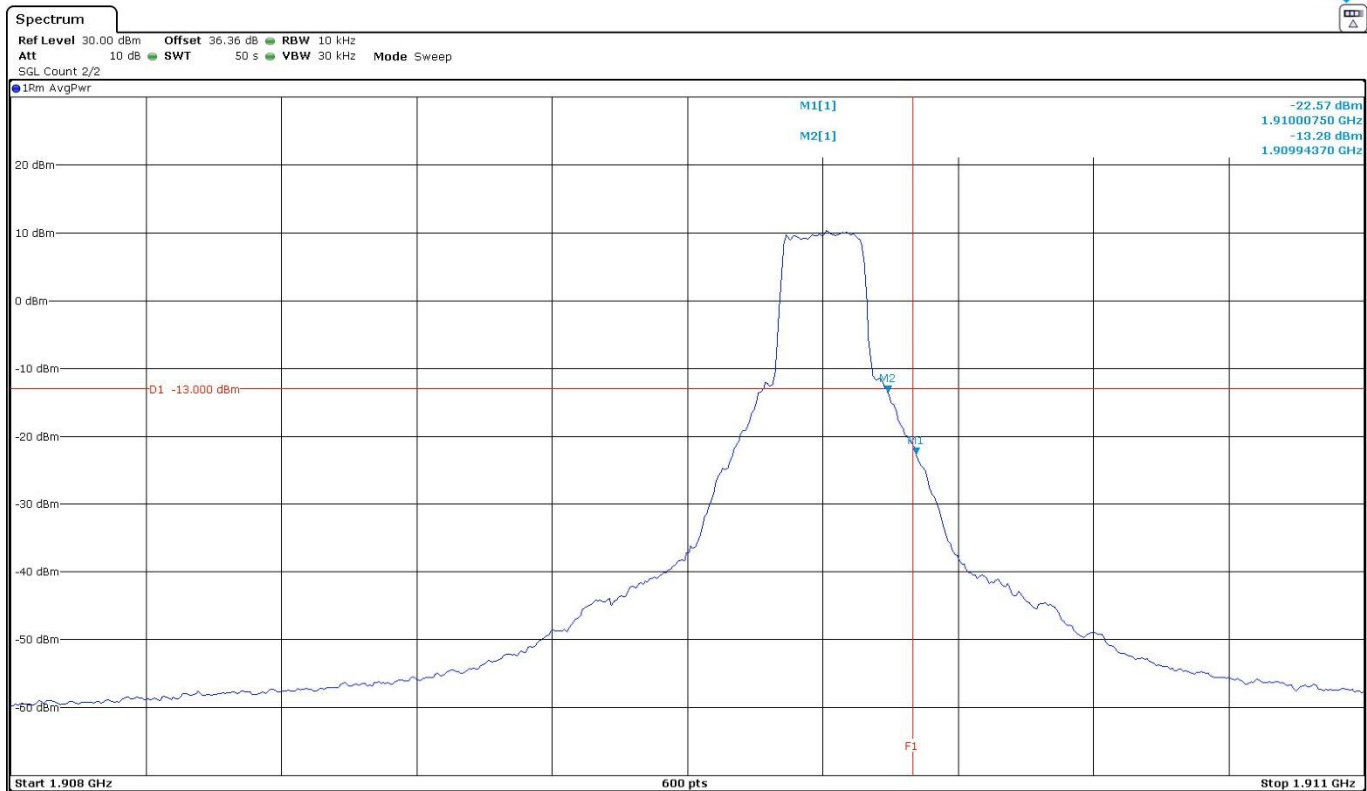
The equipment transmits at the maximum output power

LTE Cat NB2 Band 2. Pi/2-BPSK. BW=15 kHz. Tone Number=1. Tone Offset=11. MSC/TBS=0. High Channel:



The equipment transmits at the maximum output power

LTE Cat NB2 Band 2. QPSK. BW=15 kHz. Tone Number=12. Tone Offset=0. MSC/TBS=5. High Channel:



The equipment transmits at the maximum output power

LTE Cat NB2 Band 25:

Preliminary measurements determined the worst-case. Results attached are for this worst-case configuration.

LTE Cat NB2 Band 25	Pi/4-QPSK BW=3.75 kHz Tone Number=1 Tone Offset=0 MSC/TBS=0	Pi/4-QPSK BW=15 kHz Tone Number=1 Tone Offset=0 MSC/TBS=0	QPSK BW=15 kHz Tone Number=12 Tone Offset=0 MSC/TBS=5
Maximum measured level at <u>Low Block Edge</u> at antenna port (dBm)	-23.32	-23.13	-22.74

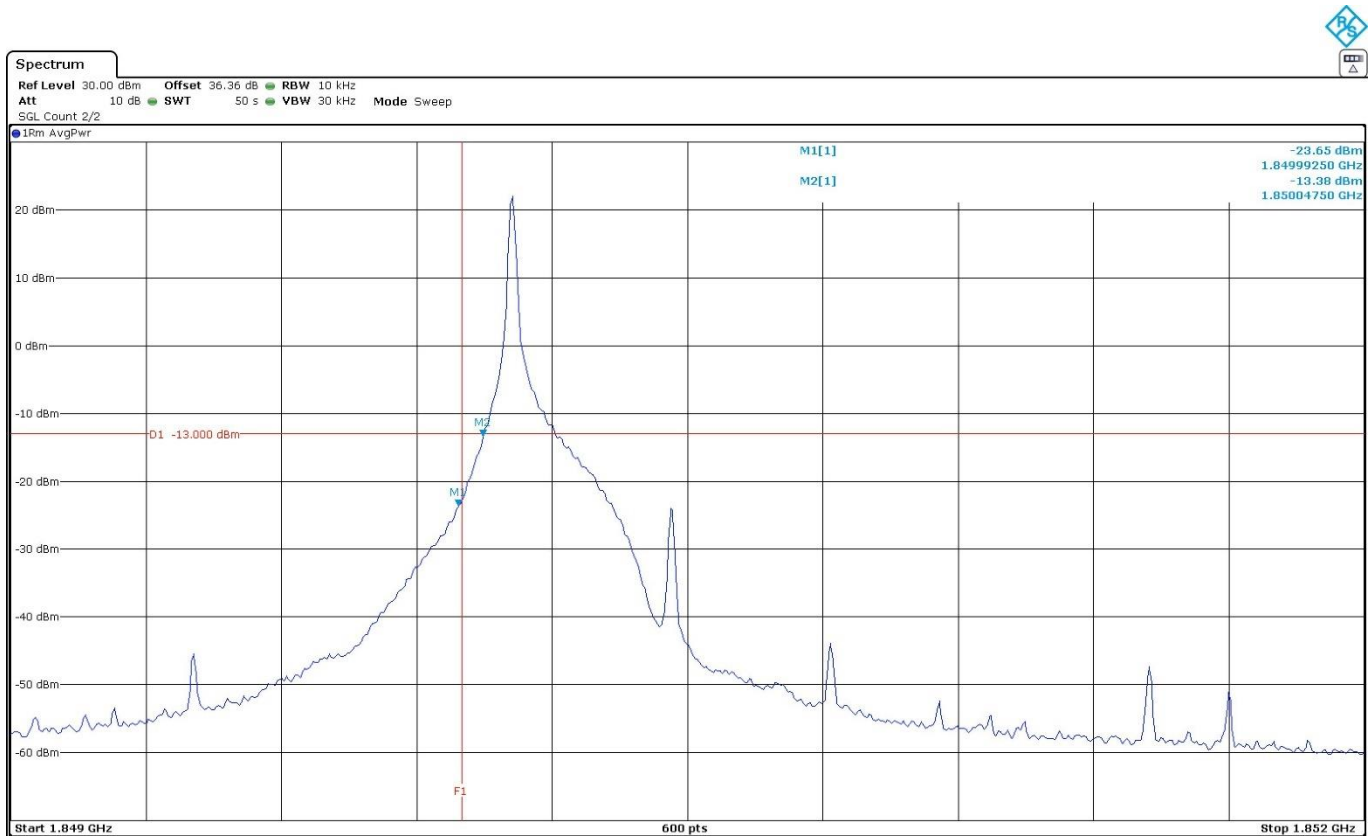
LTE Cat NB2 Band 25	Pi/4-QPSK BW=3.75 kHz Tone Number=1 Tone Offset=47 MSC/TBS=0	Pi/4-QPSK BW=15 kHz Tone Number=1 Tone Offset=11 MSC/TBS=0	QPSK BW=15 kHz Tone Number=12 Tone Offset=0 MSC/TBS=5
Maximum measured level at <u>High Block Edge</u> at antenna port (dBm)	-23.85	-23.01	-22.88

Measurement uncertainty (dB): <±2.76

Verdict

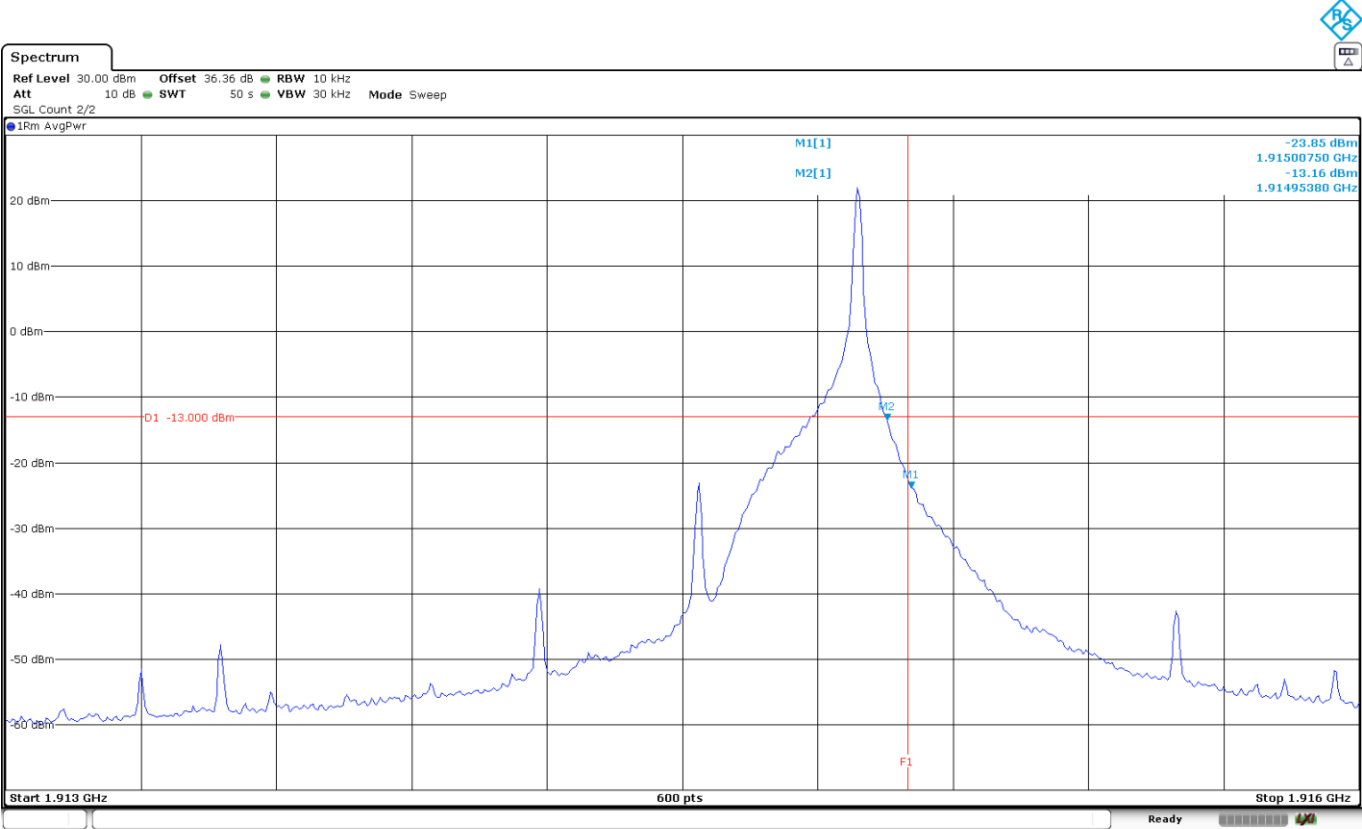
Pass

LTE Cat NB2 Band 25. Pi/4-QPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=0. Low Channel:



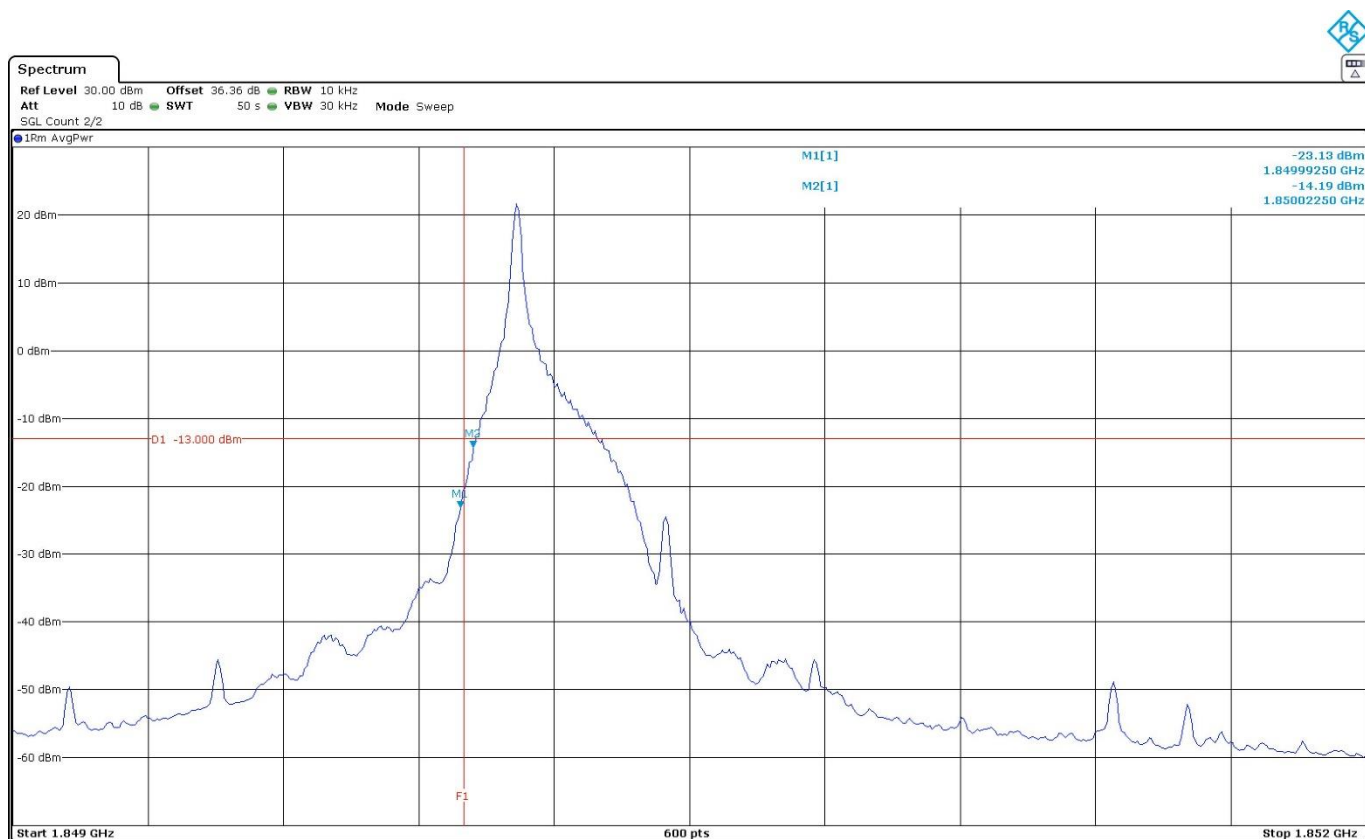
The equipment transmits at the maximum output power

LTE Cat NB2 Band 25. Pi/4-QPSK. BW=3.75 kHz. Tone Number=1. Tone Offset=47. MSC/TBS=0. High Channel:



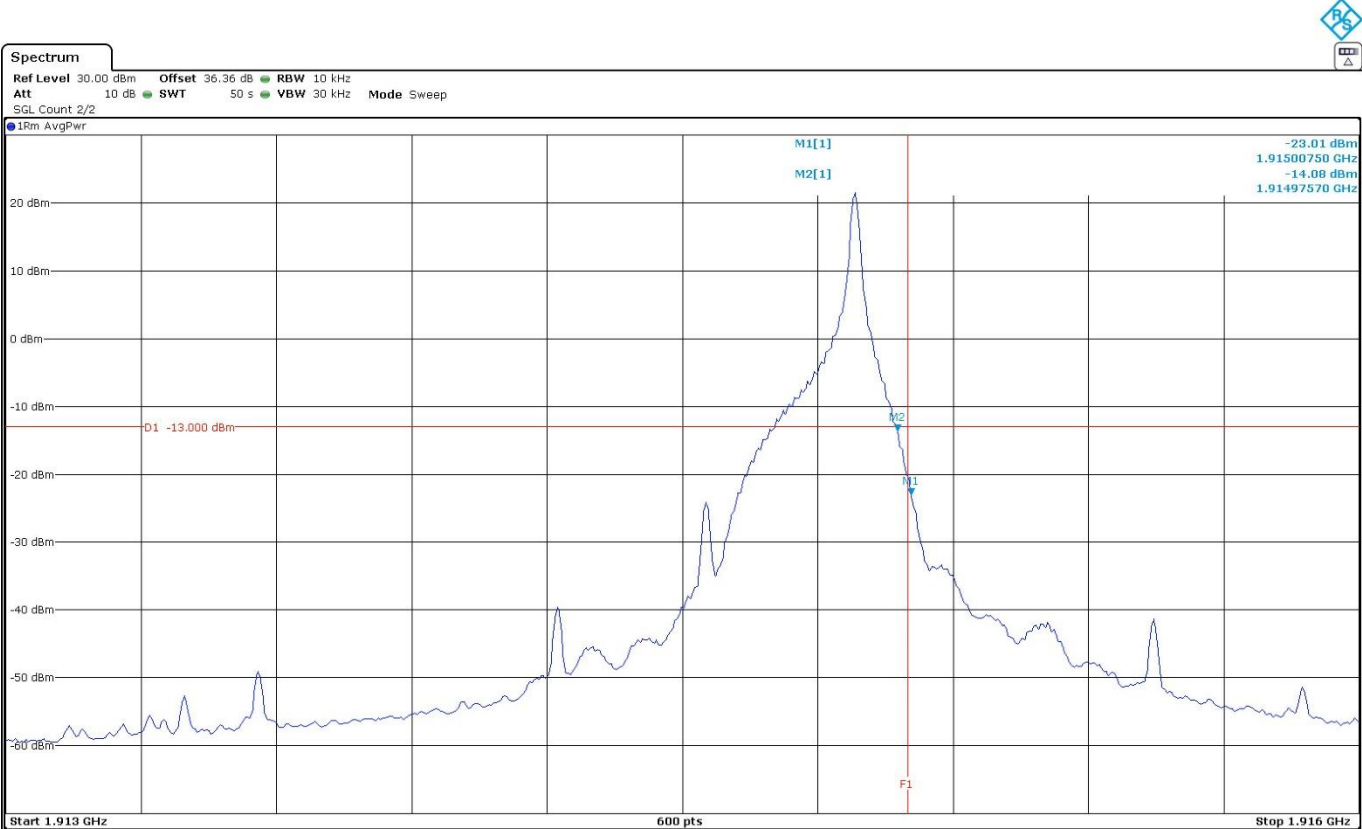
The equipment transmits at the maximum output power

LTE Cat NB2 Band 25. Pi/4-QPSK. BW=15 kHz. Tone Number=1. Tone Offset=0. MSC/TBS=0. Low Channel:



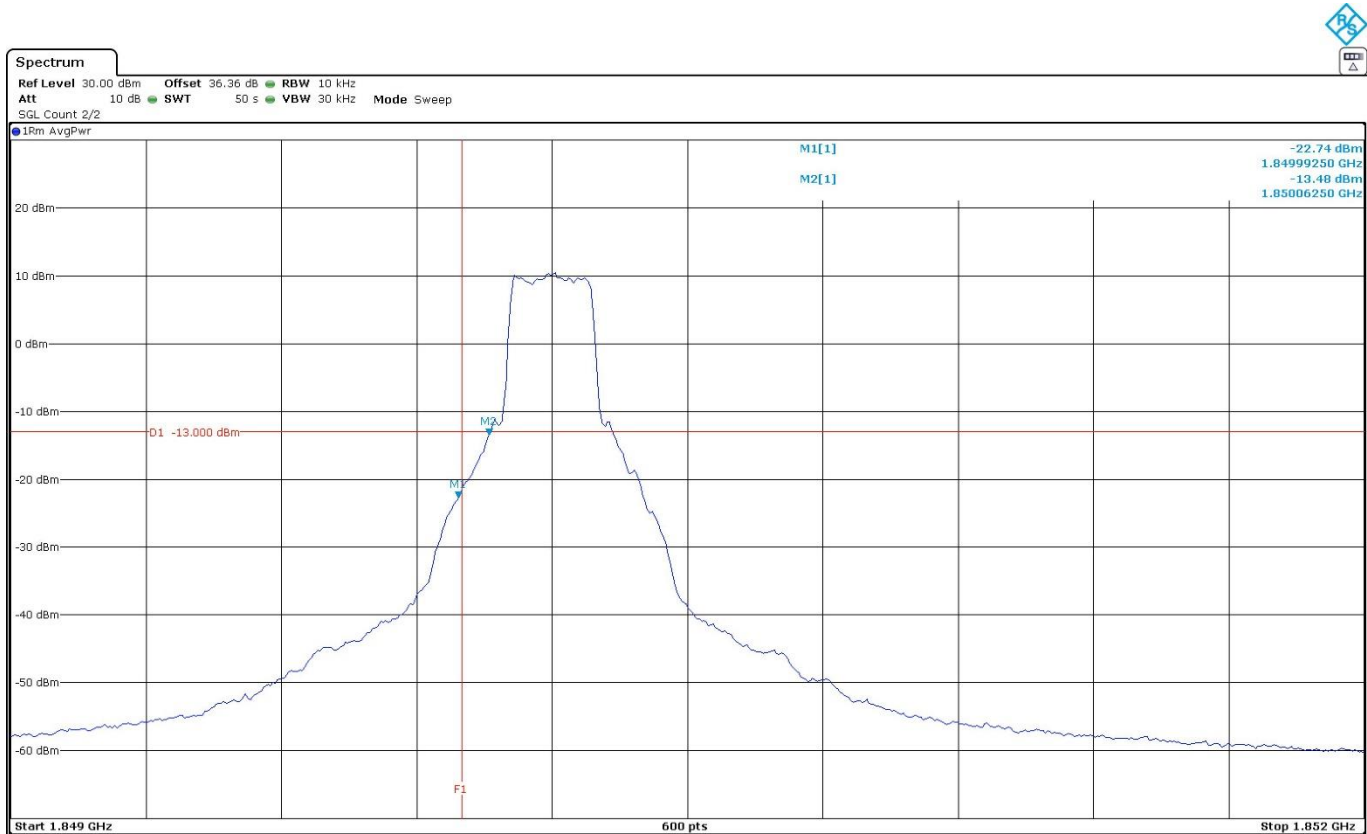
The equipment transmits at the maximum output power

LTE Cat NB2 Band 25. Pi/4-QPSK. BW=15 kHz. Tone Number=1. Tone Offset=11. MSC/TBS=0. High Channel:



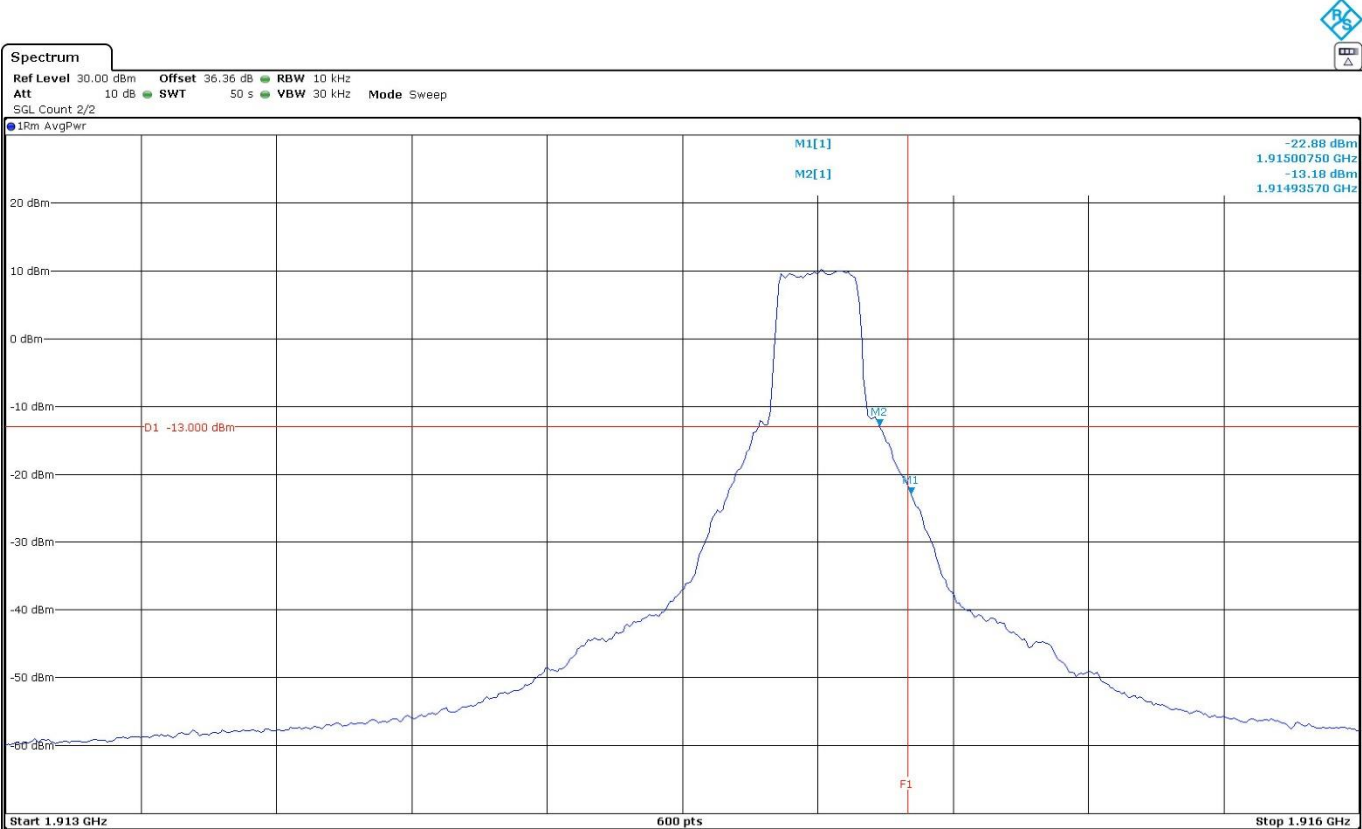
The equipment transmits at the maximum output power

LTE Cat NB2 Band 25. QPSK. BW=15 kHz. Tone Number=12. Tone Offset=0. MSC/TBS=5. Low Channel:



The equipment transmits at the maximum output power

LTE Cat NB2 Band 25. QPSK. BW=15 kHz. Tone Number=12. Tone Offset=0. MSC/TBS=5. High Channel:



The equipment transmits at the maximum output power

Radiated emissions

Limits

FCC § 24.238. RSS-133 Clause 6.5.

The power of emissions shall be attenuated below the transmitter power (P) by a factor of at least $43 + 10 \log (P)$ dB. P in watts.

Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 1 MHz or greater.

Method

The measurement was performed with the EUT inside an anechoic chamber. The spectrum was scanned from 30 MHz to at least the 10th harmonic of the High frequency generated within the equipment.

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

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

Measurement Limit:

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

$$P_o \text{ (dBm)} - [43 + 10 \log (P_o \text{ in mwatts}) - 30] = -13 \text{ dBm}$$

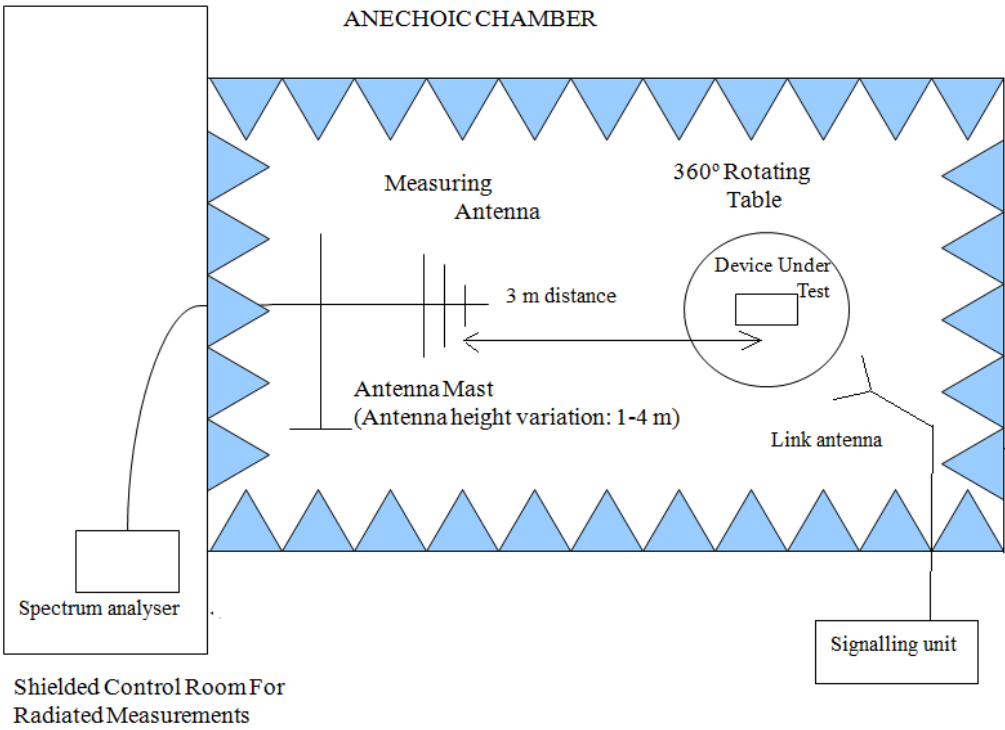
The maximum field strength (dB μ V/m) of each detected emission at less than 20 dB respect to the limit is converted to an equivalent EIRP level (dBm) according to ANSI C63.26 with the formula:

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

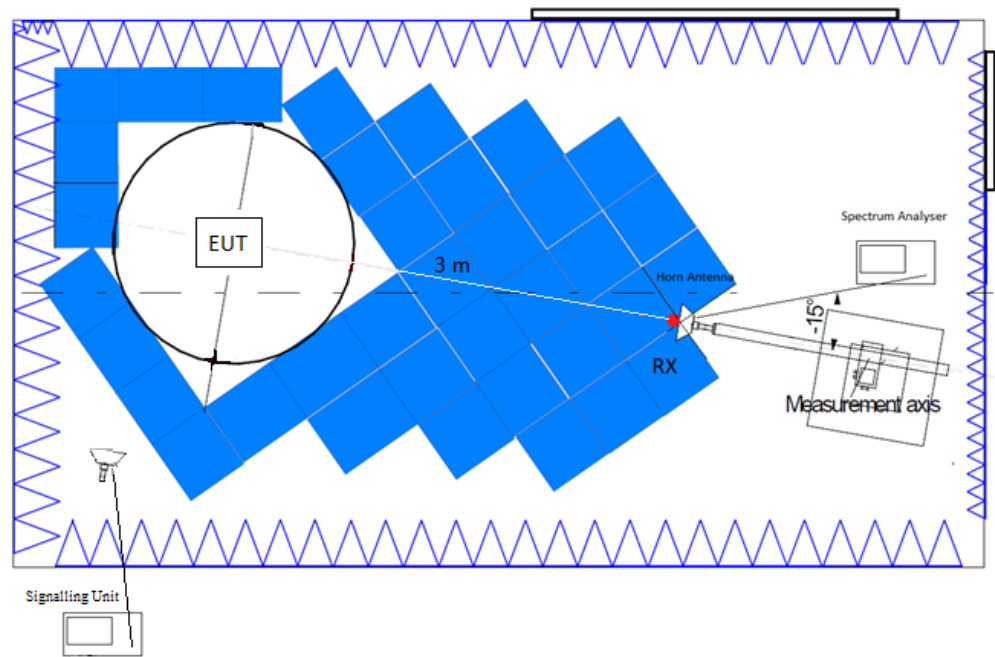
where D is the measurement distance (in the far field region) in m.

Test Setup

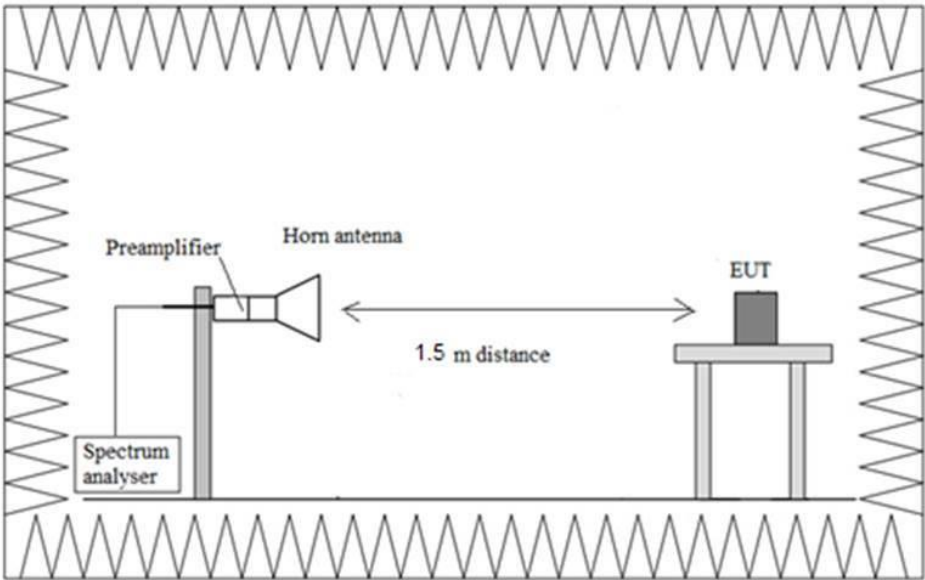
Radiated measurements below 1 GHz:



Radiated measurements above 1 GHz up to 17 GHz:



Radiated measurements above 17 GHz:



Results

LTE Cat NB2 Band 25:

NOTE: testing performed on S/02

A preliminary scan determined the Pi/2-BPSK, BW=15 kHz, Tone Number=1, Tone Offset=0, MSC/TBS=0 as the worst case. The following results are for this worst-case configuration.

- LOW CHANNEL:

- Frequency range 30 MHz - 1 GHz:
No spurious signals were found at less than 20 dB below the limit.
- Frequency range 1 - 17 GHz:
No spurious signals were found at less than 20 dB below the limit.
- Frequency range 17 - 20 GHz:
No spurious signals were found at less than 20 dB below the limit.

- MIDDLE CHANNEL:

- Frequency range 30 MHz - 1 GHz:
Spurious signals were found at less than 20 dB below the limit:

Spurious frequency (MHz)	E.I.R.P (dBm)	Polarization	Detector
38.942188	-31.33	V	Peak

- Frequency range 1 - 17 GHz:
No spurious signals were found at less than 20 dB below the limit.
- Frequency range 17 - 20 GHz:
No spurious signals were found at less than 20 dB below the limit.

- HIGH CHANNEL:

- Frequency range 30 MHz - 1 GHz:
Spurious signals were found at less than 20 dB below the limit:

Spurious frequency (MHz)	E.I.R.P (dBm)	Polarization	Detector
38.881563	-31.75	V	Peak

- Frequency range 1 - 17 GHz:
No spurious signals were found at less than 20 dB below the limit.
- Frequency range 17 - 20 GHz:
No spurious signals were found at less than 20 dB below the limit.

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

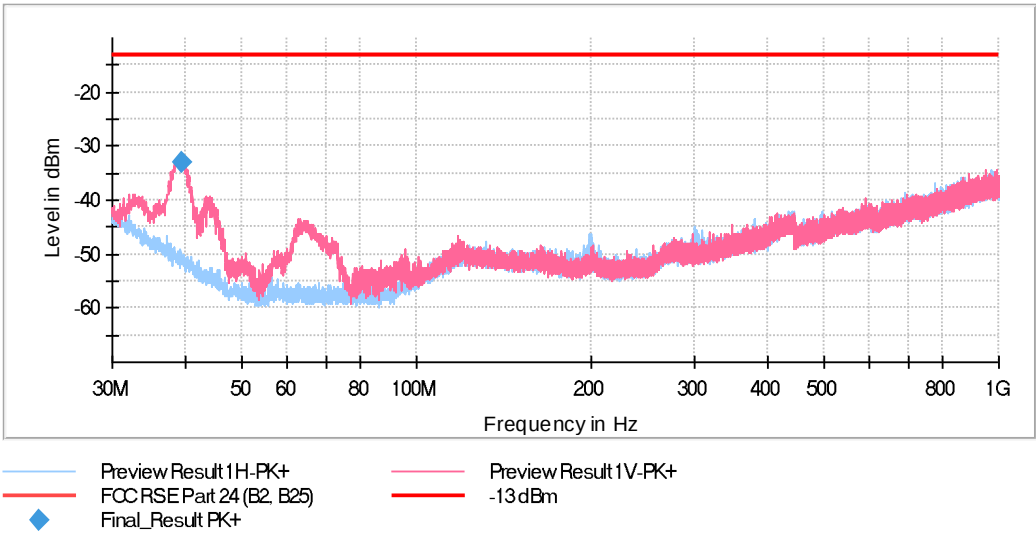
Verdict

Pass

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
30 MHz - 1 GHz	30.312 kHz	PK+	1 MHz	Coupled	0 dB
1 GHz - 3 GHz	62.5 kHz	PK+	1 MHz	1 s	0 dB
3 GHz - 17 GHz	437.5 kHz	PK+	1 MHz	1 s	0 dB
17 GHz - 20 GHz	93.75 kHz	PK+	1 MHz	1 s	0 dB

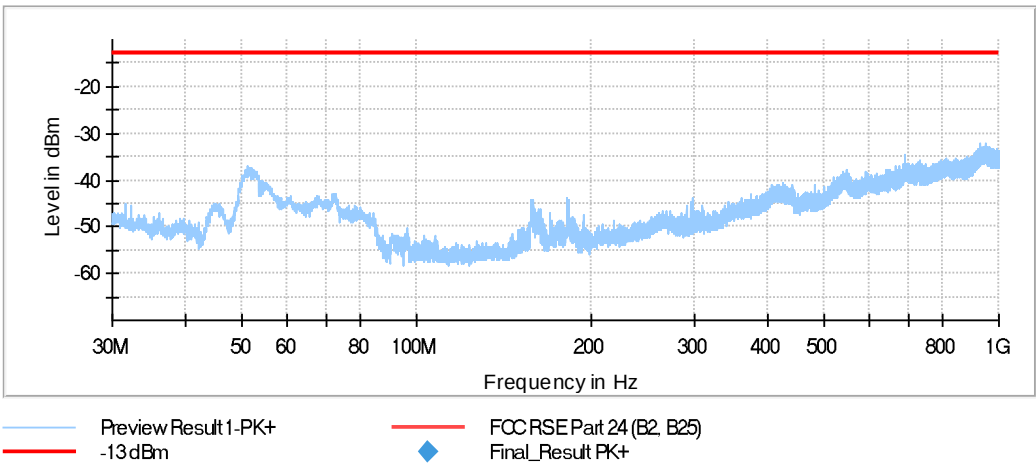
FREQUENCY RANGE 30 MHz - 1 GHz:

- Low Channel:

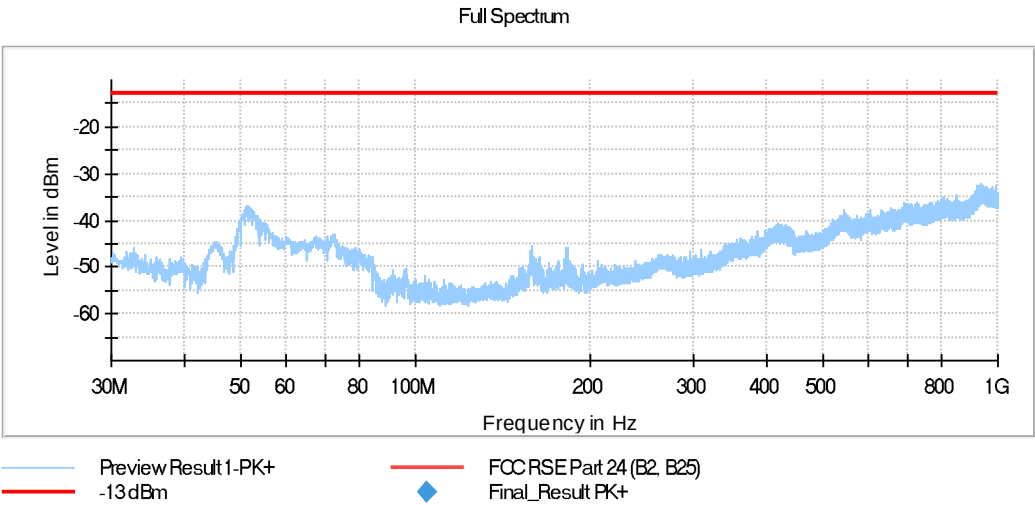


- Middle Channel:

Full Spectrum

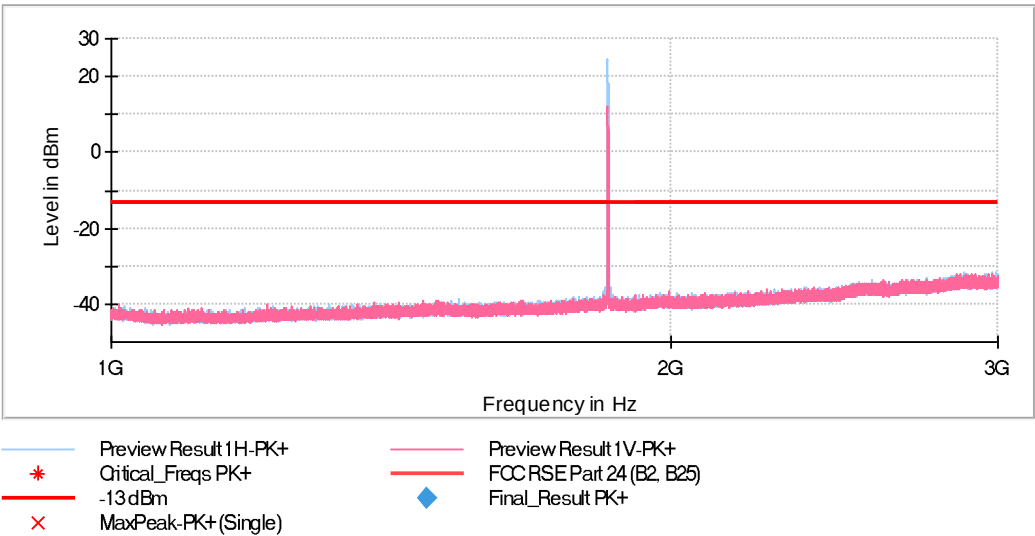


- High Channel:



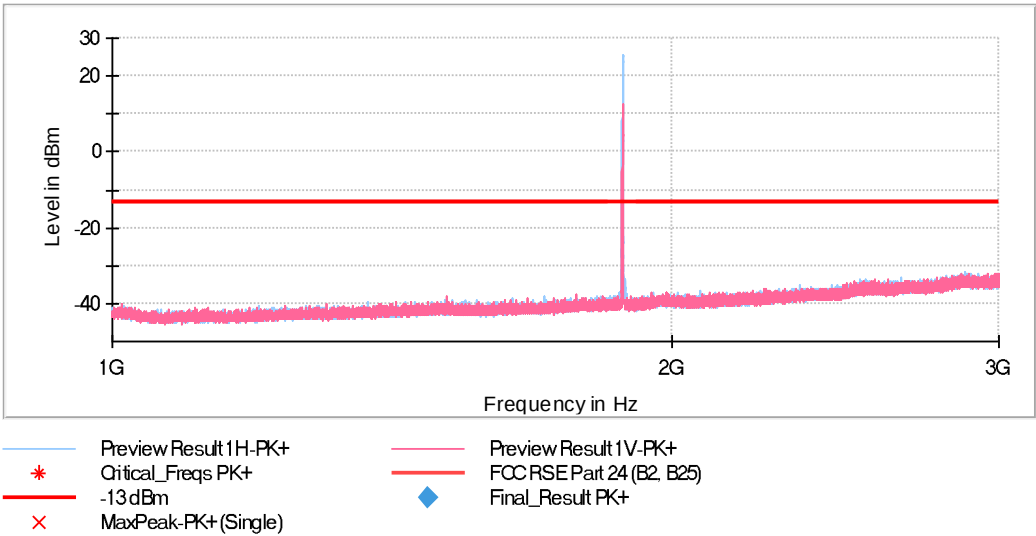
FREQUENCY RANGE 1 - 3 GHz:

- Low Channel:



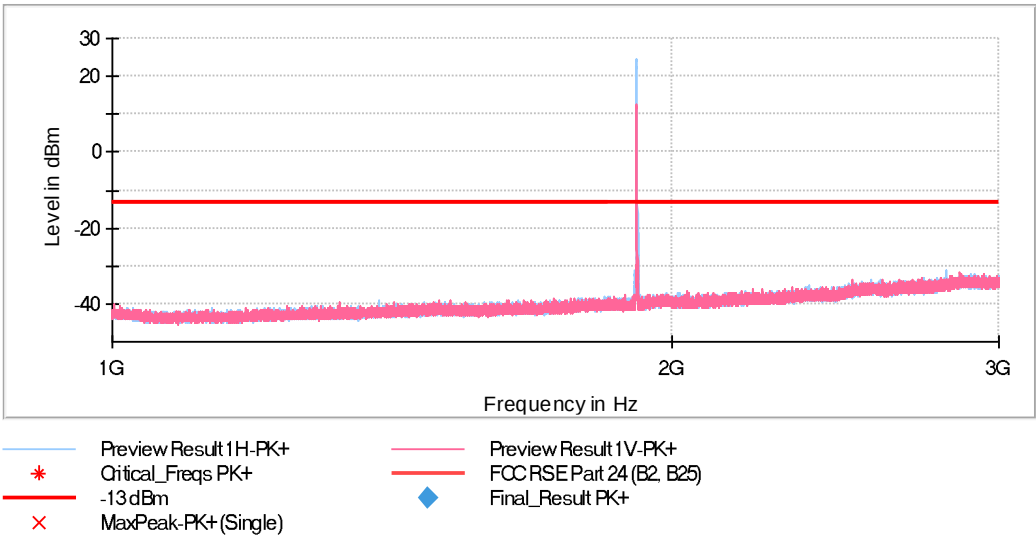
The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.

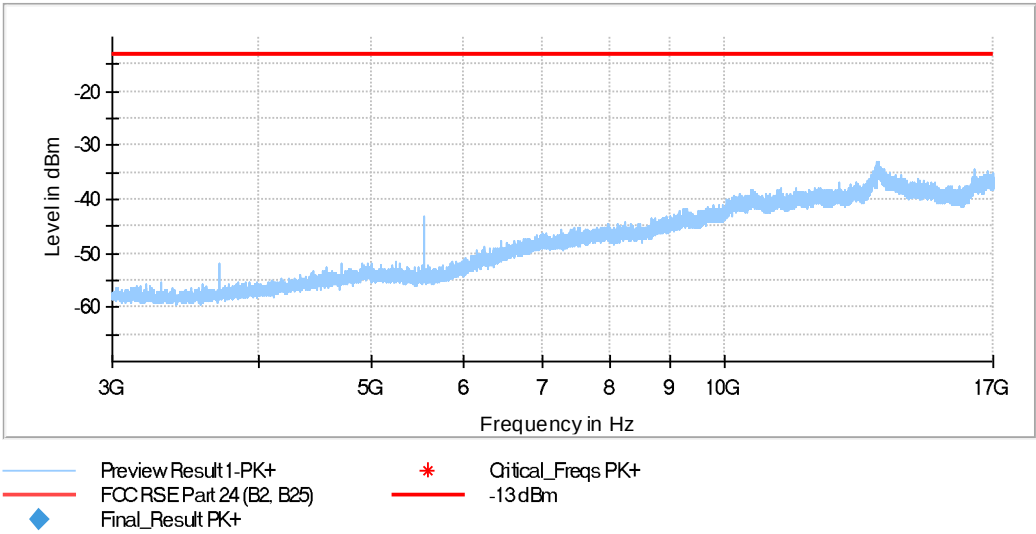
- High Channel:



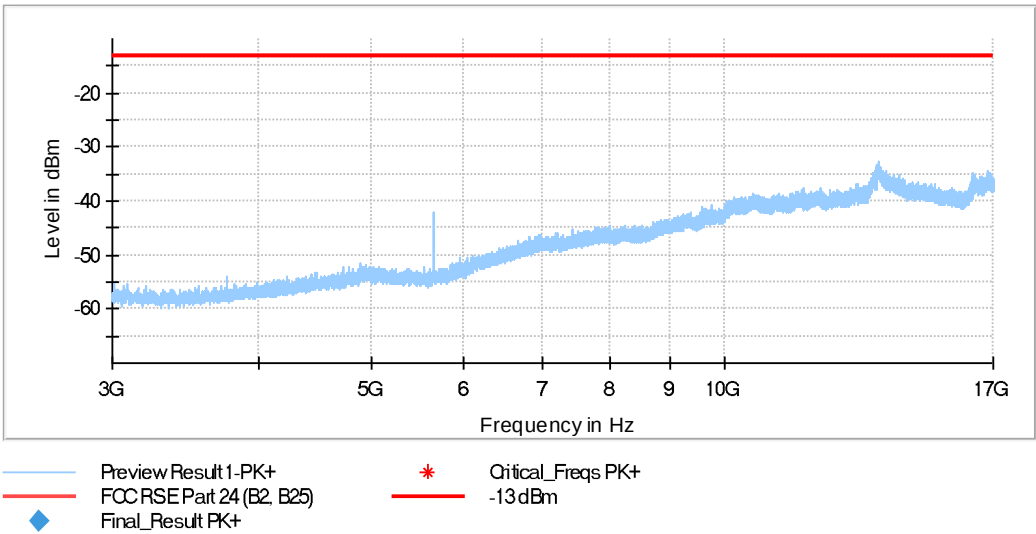
The peak above the limit is the carrier frequency.

FREQUENCY RANGE 3 - 17 GHz:

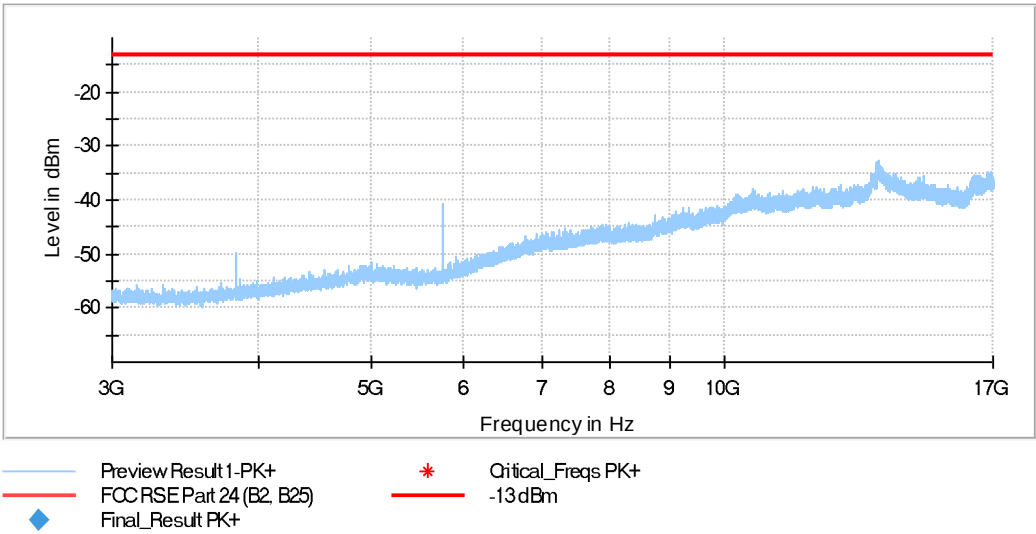
- Low Channel:



- Middle Channel:

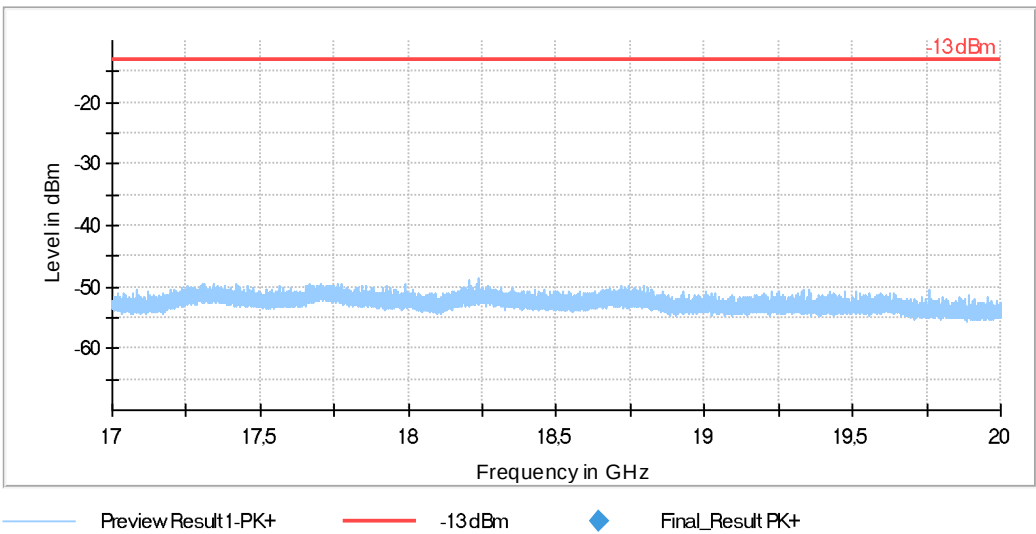


- High Channel:

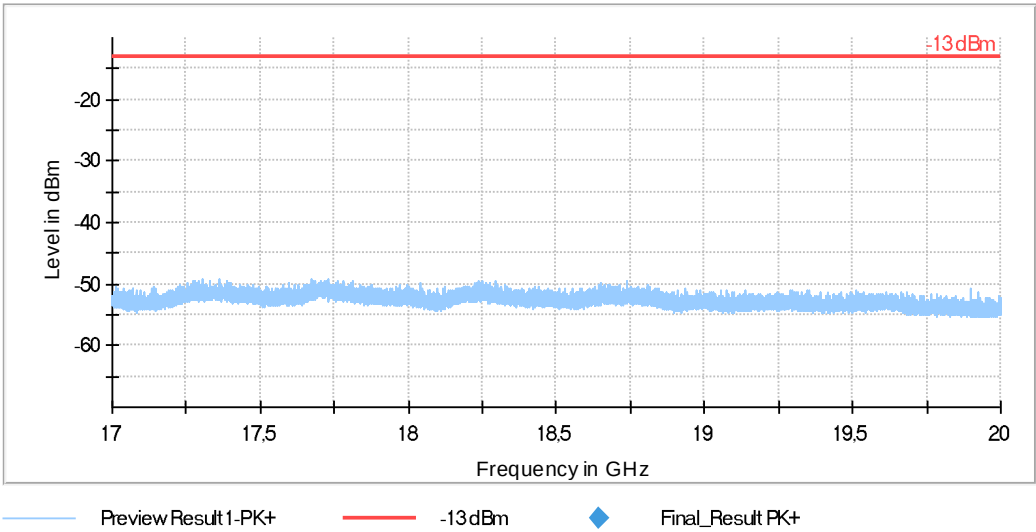


FREQUENCY RANGE 17 - 20 GHz:

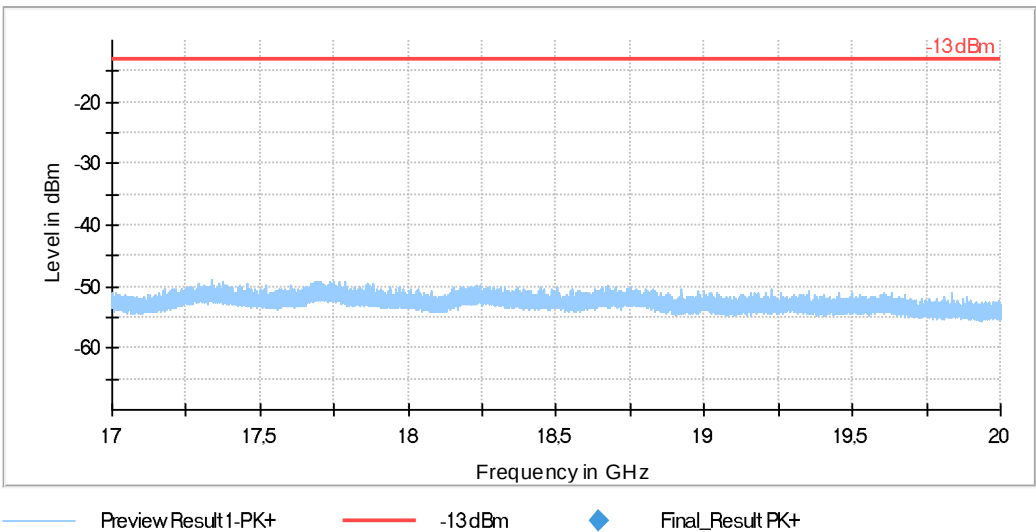
- Low Channel:



- Middle Channel:



- High Channel:



LTE Cat NB2 Band 25:

NOTE: testing performed on S/04

A preliminary scan determined the Pi/2-BPSK, BW=15 kHz, Tone Number=1, Tone Offset=0, MSC/TBS=0 as the worst case. The following results are for this worst-case configuration.

- LOW CHANNEL:

Frequency range 30 MHz - 1 GHz:

Spurious signals were found at less than 20 dB below the limit.

Spurious frequency (MHz)	E.I.R.P (dBm)	Polarization	Detector
38.699688	-27.68	V	Peak

Frequency range 1 - 17 GHz:

Spurious signals were found at less than 20 dB below the limit.

Spurious frequency (MHz)	E.I.R.P (dBm)	Polarization	Detector
13537.625000	-31.93	V	Peak

Frequency range 17 - 20 GHz:

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

Measurement uncertainty (dB) $\leq \pm 5.03$ for $f < 1$ GHz
 $\leq \pm 4.32$ for $f \geq 1$ GHz up to 17 GHz
 $\leq \pm 4.58$ for $f \geq 17$ GHz up to 20 GHz

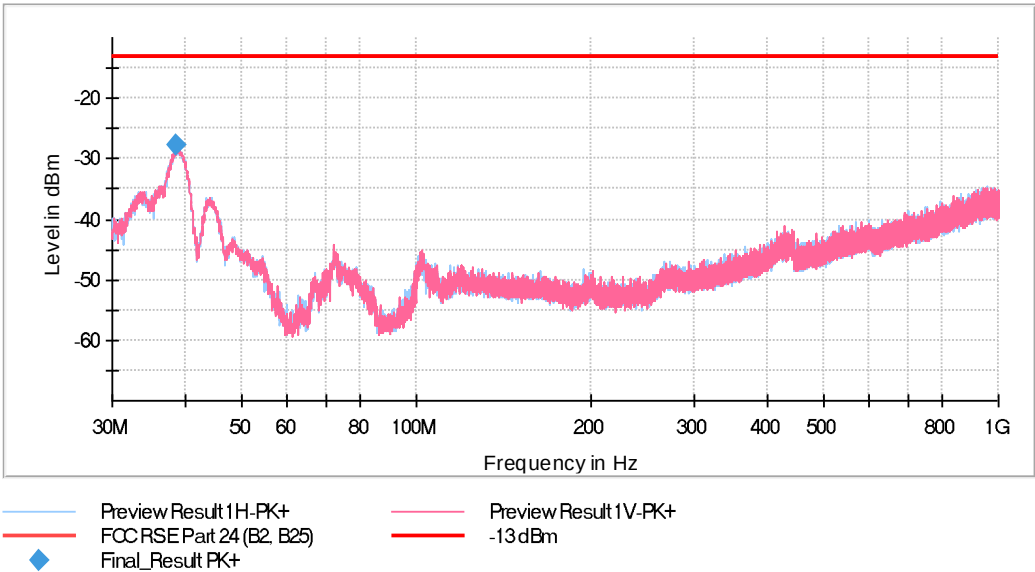
Verdict

Pass

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
30 MHz - 1 GHz	30.312 kHz	PK+	1 MHz	Coupled	0 dB
1 GHz - 3 GHz	62.5 kHz	PK+	1 MHz	1 s	0 dB
3 GHz - 17 GHz	437.5 kHz	PK+	1 MHz	1 s	0 dB
17 GHz - 20 GHz	93.75 kHz	PK+	1 MHz	1 s	0 dB

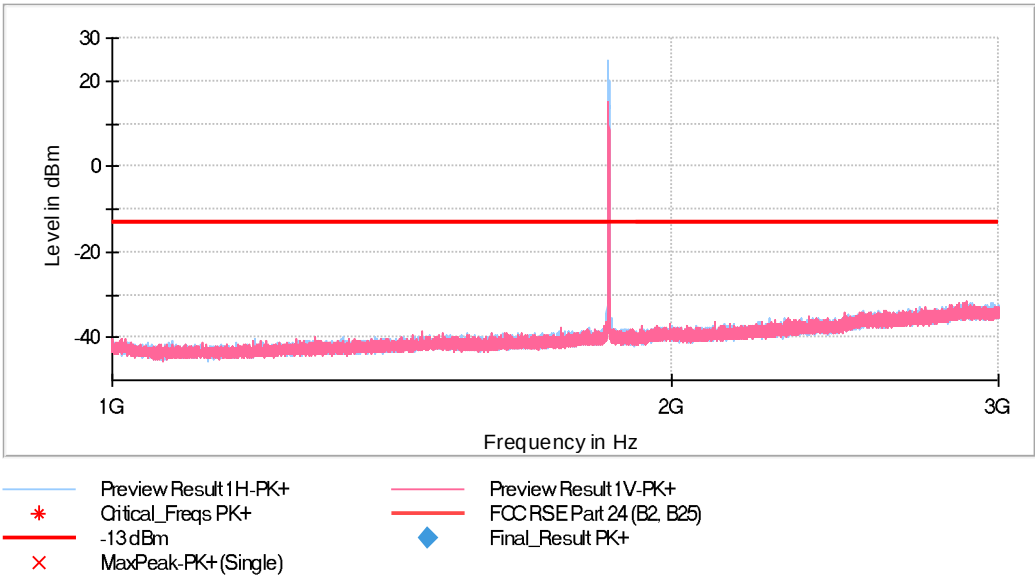
FREQUENCY RANGE 30 MHz - 1 GHz:

- Low Channel:



FREQUENCY RANGE 1 - 3 GHz:

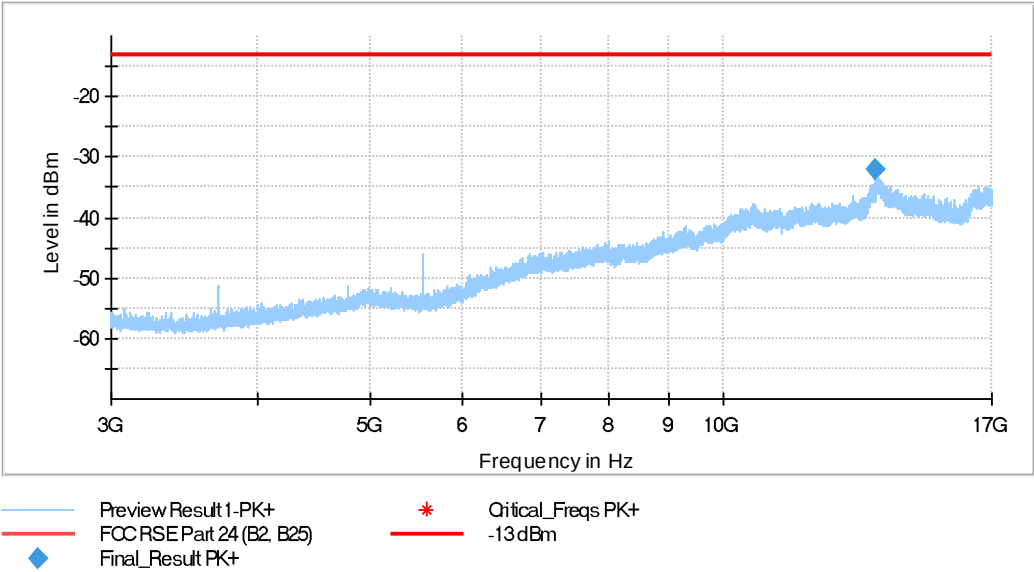
- Low Channel:



The peak above the limit is the carrier frequency.

FREQUENCY RANGE 3 - 17 GHz:

- Low Channel:



FREQUENCY RANGE 17 - 20 GHz:

- Low Channel:

