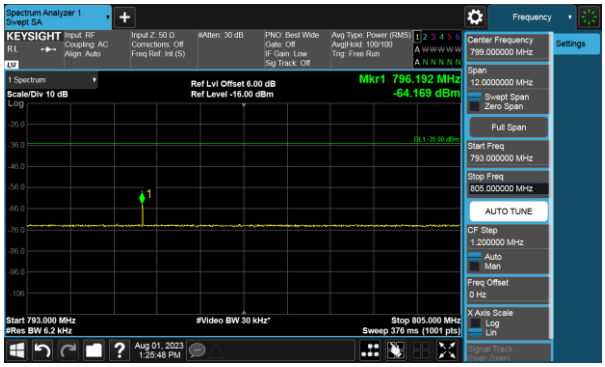
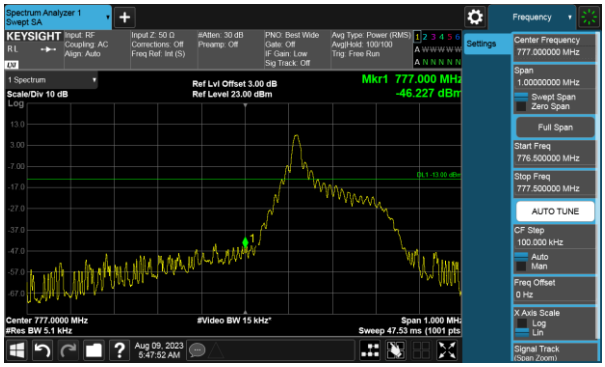
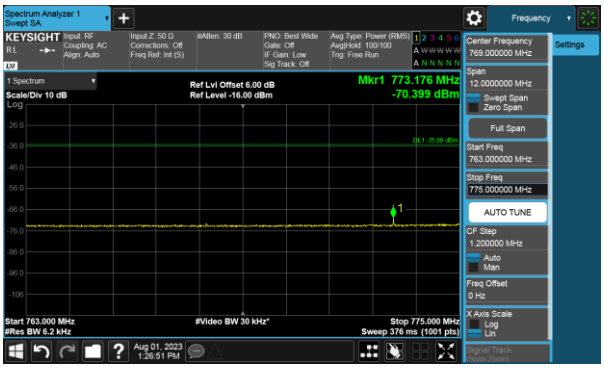
NB-IoT
LTE Band 13 BPSK 15KHz 1@0 CH 23182

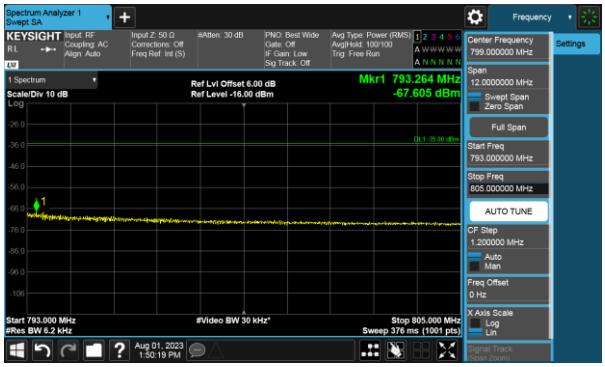




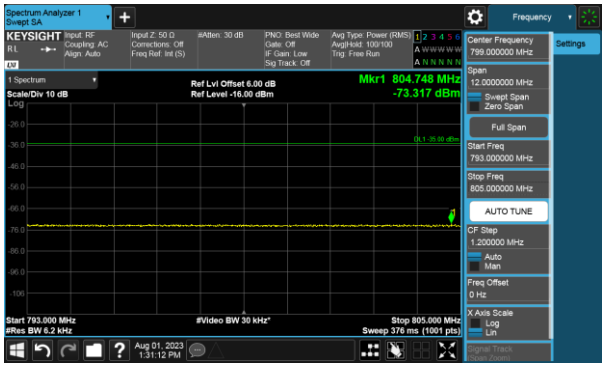


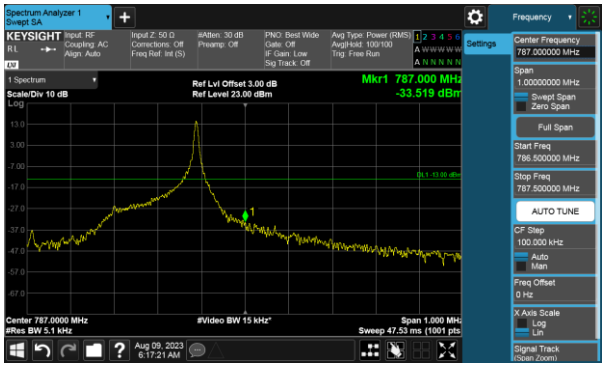
NB-IoT

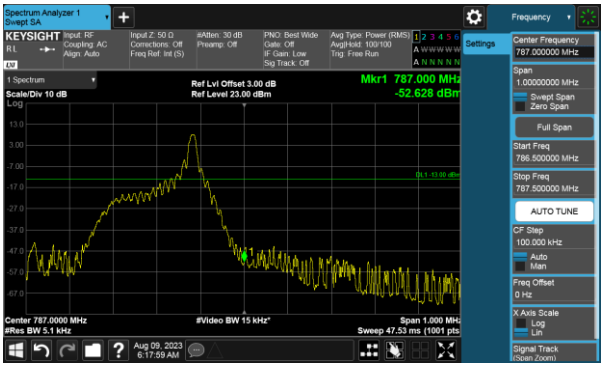
LTE Band 13 QPSK 3.75KHz 1@47 CH 23278

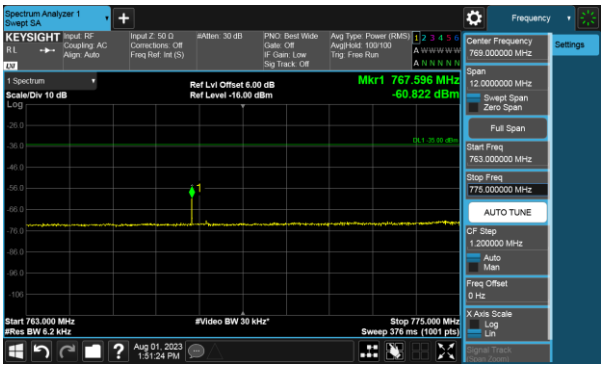


LTE Band 13 QPSK 15KHz 1@11 CH 23278



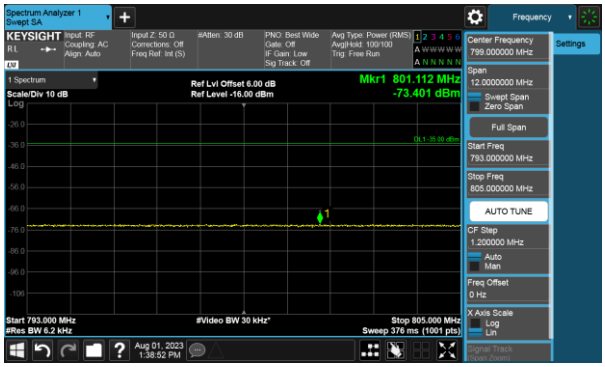




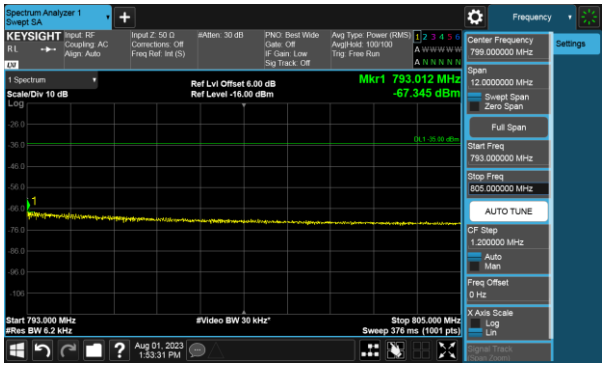


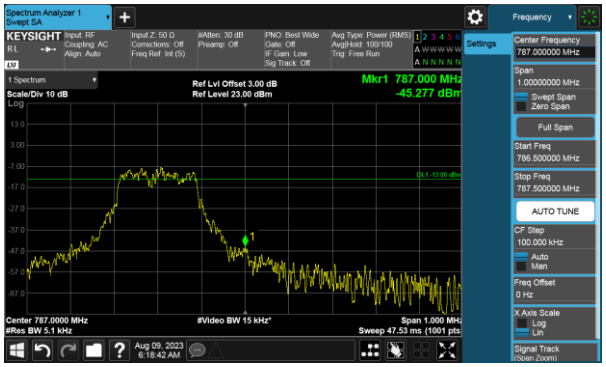
NB-IoT

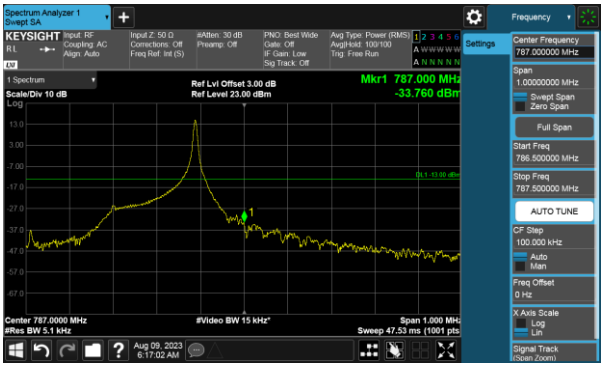
LTE Band 13 QPSK 15KHz 12@0 CH 23278

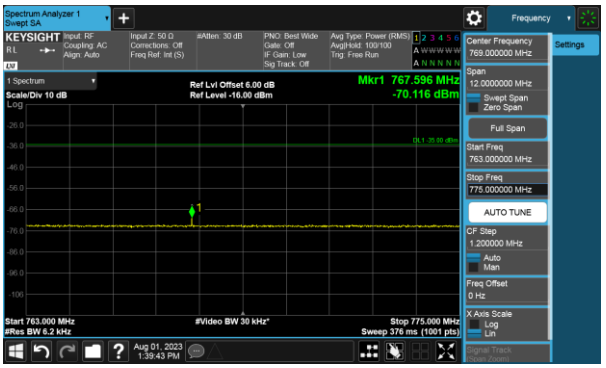


LTE Band 13 BPSK 3.75KHz 1@47 CH 23278

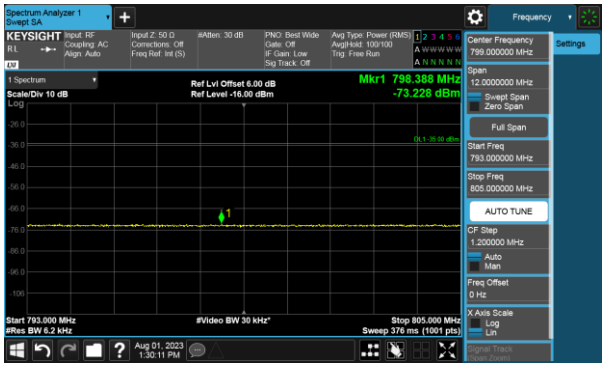


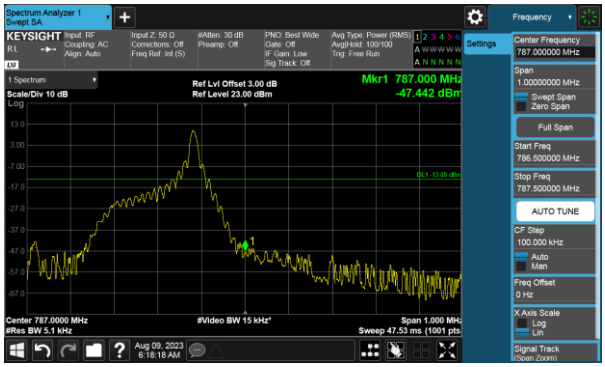


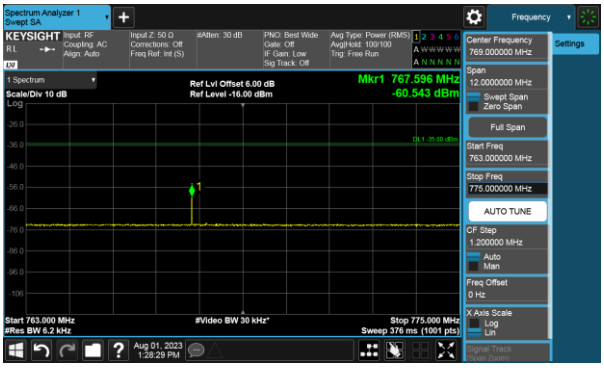




NB-IoT
LTE Band 13 BPSK 15KHz 1@11 CH 23278







9. Conducted Spurious Emission Test

9.1. Test Limit

For LTE Band 4:

In the FCC 27.53(h)(4):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.

For LTE Band 12:

According to 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.

For LTE Band 13:

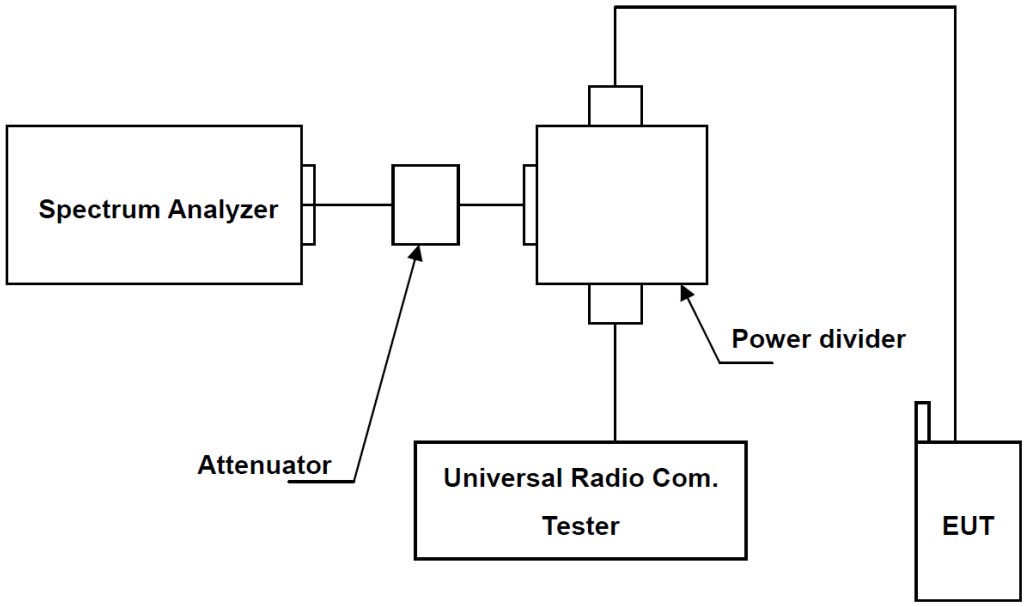
According to FCC 27.53(c)(2) for on any frequency outside the 776-788 MHz band, the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least 43 + 10 log (P) dB.

According to FCC 27.53(f) for operations in the 775-788 MHz, emissions in the band 1559-1610 MHz shall be limited to -70 dBW/MHz. The limit of emissions is equal to -40 dBm.

9.2. Test Procedures

a. The EUT was set up for the maximum peak power with WWAN link data modulation. The power was measured with Spectrum Analyzer. All measurements were done at 3 channels (low, middle and high operational frequency range.)
b. The conducted spurious emission used the power splitter via EUT RF power connector between simulation base station and spectrum analyzer.
c. When the spectrum scanned from 30MHz to 1GHz. The spectrum set RBW=100KHz, VBW=300KHz.
d. When the spectrum scanned from Above 1GHz. The spectrum set RBW=1MHz, VBW=3MHz.

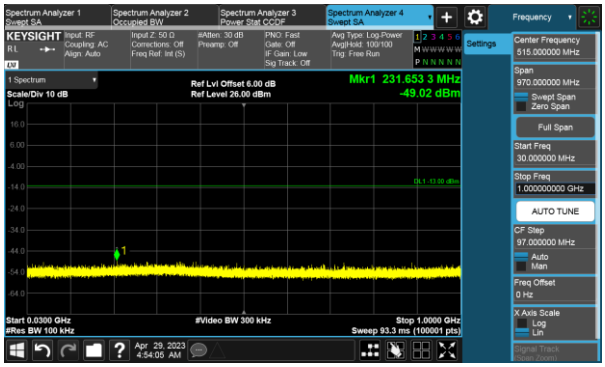
9.3. Test Setup



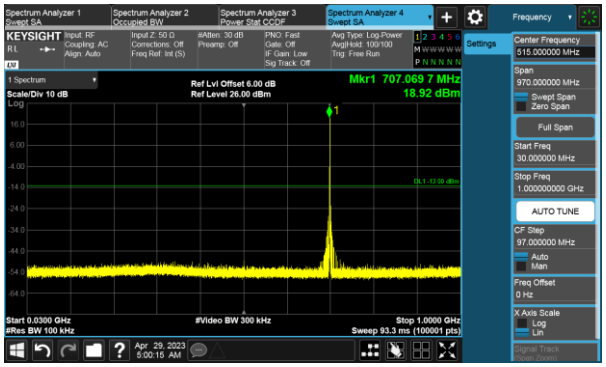
9.4. Test Result and Data

Cat M1

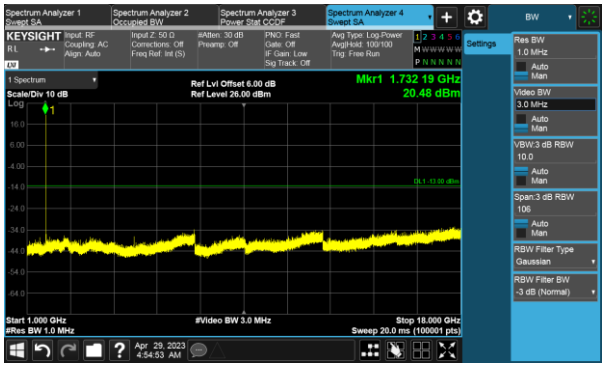
LTE Band 4 QPSK 1.4MHz, CH 20175



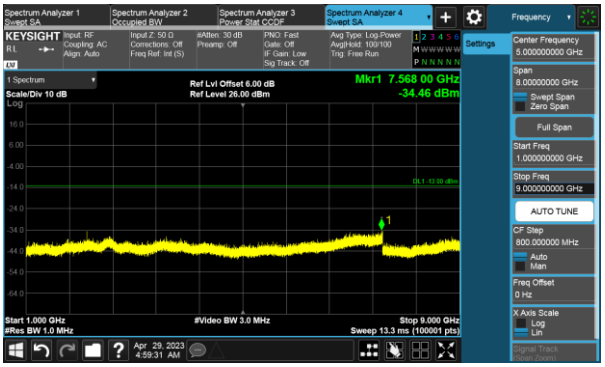
LTE Band 12 QPSK 1.4MHz, CH 23095



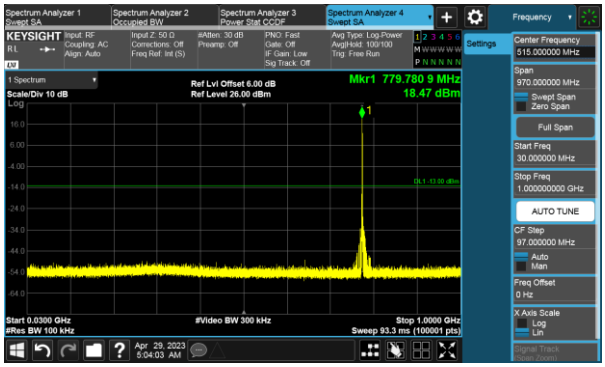
LTE Band 4 QPSK 1.4MHz, CH 20175



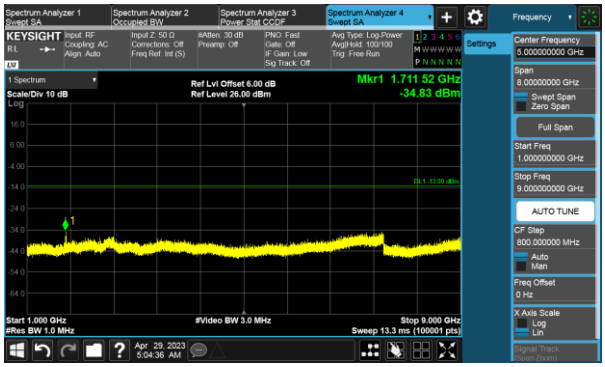
LTE Band 12 QPSK 1.4MHz, CH 23095



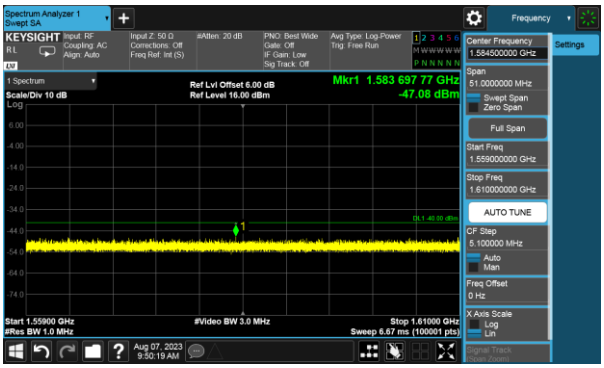
Cat M1
LTE Band 13 QPSK 1.4MHz, CH 23230



LTE Band 13 QPSK 1.4MHz, CH 23230

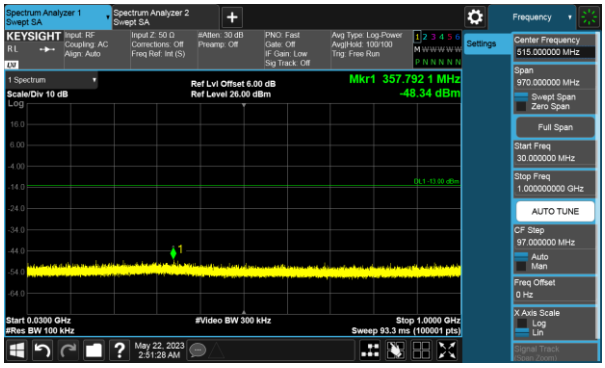


LTE Band 13 QPSK 1.4MHz, CH 23230

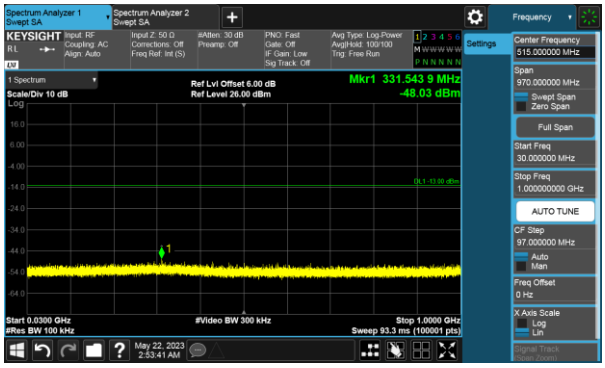


NB-IoT

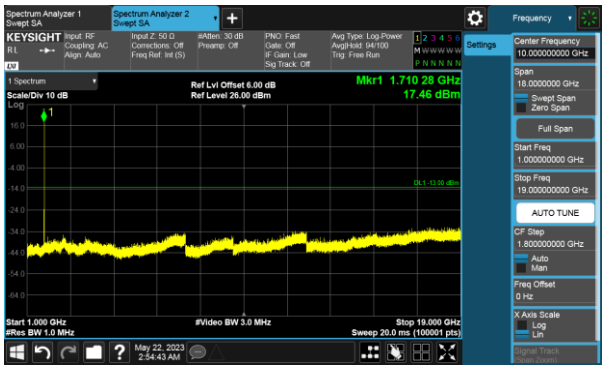
LTE Band 4 QPSK, CH 19952



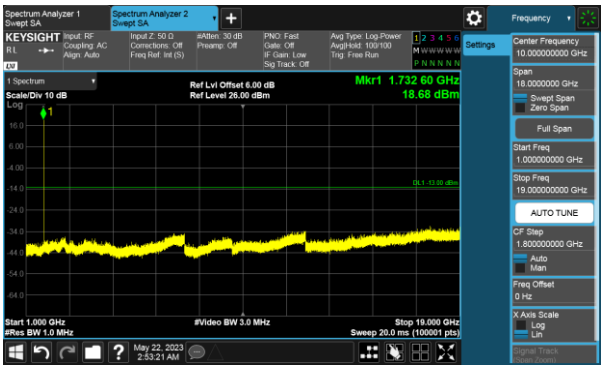
LTE Band 4 QPSK, CH 20175



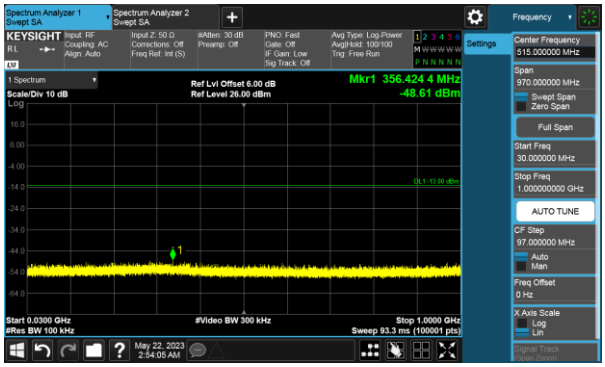
LTE Band 4 QPSK, CH 19952



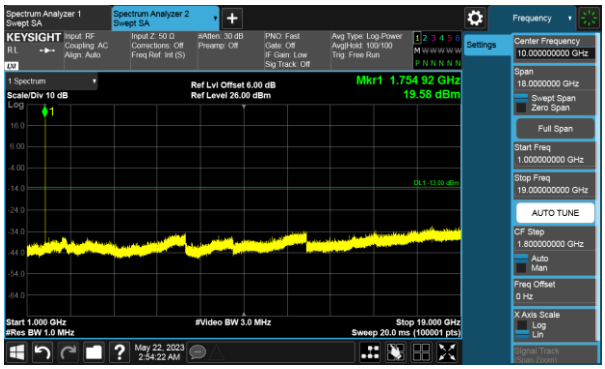
LTE Band 4 QPSK, CH 20175



NB-IoT
LTE Band 4 QPSK, CH 20398

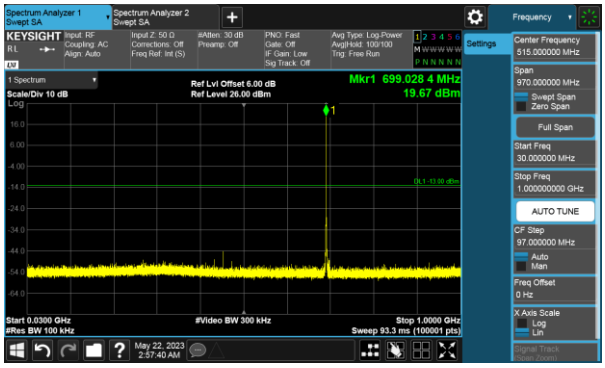


LTE Band 4 QPSK, CH 20398

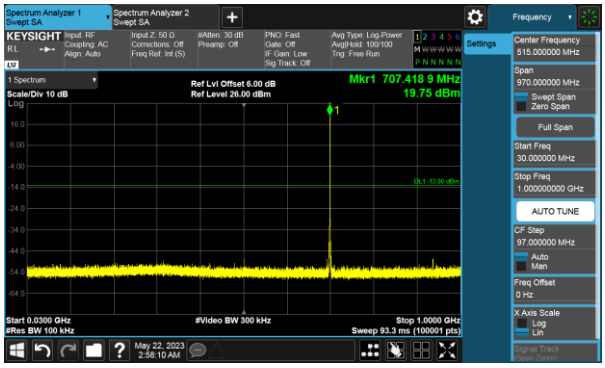


NB-IoT

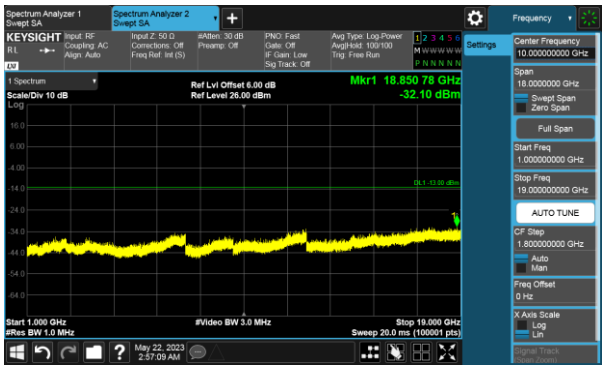
LTE Band 12 QPSK, CH 23012



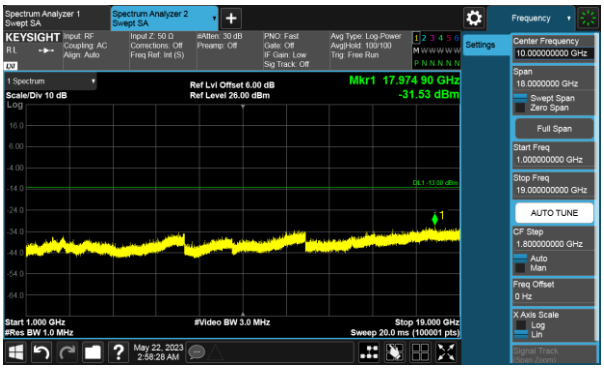
LTE Band 12 QPSK, CH 23095



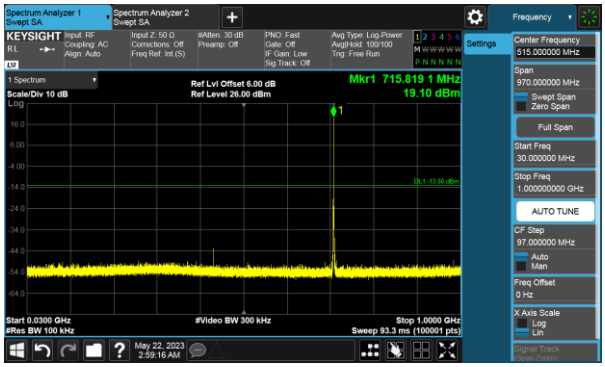
LTE Band 12 QPSK, CH 23012



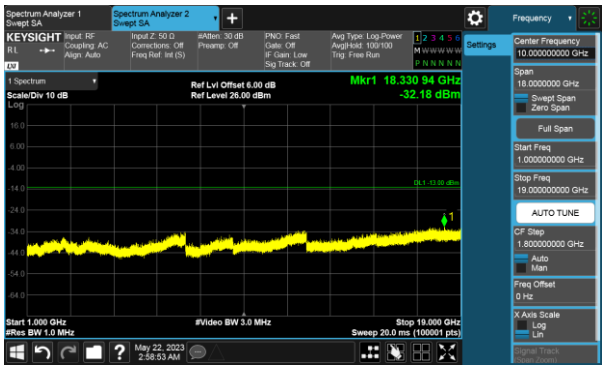
LTE Band 12 QPSK, CH 23095



NB-IoT
LTE Band 12 QPSK, CH 23178

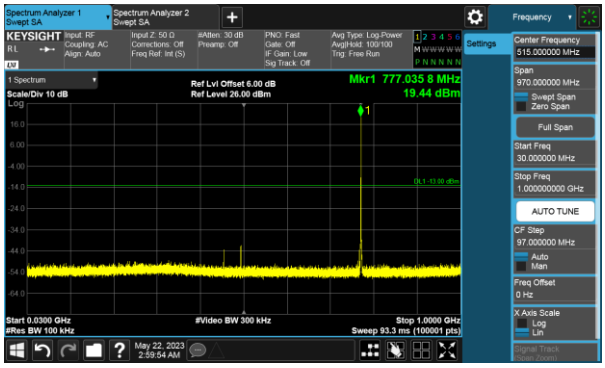


LTE Band 12 QPSK, CH 23178

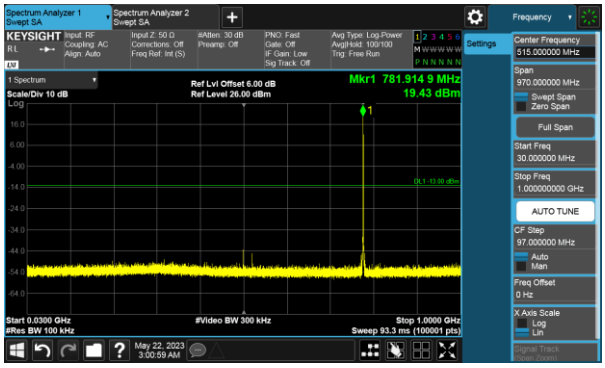


NB-IoT

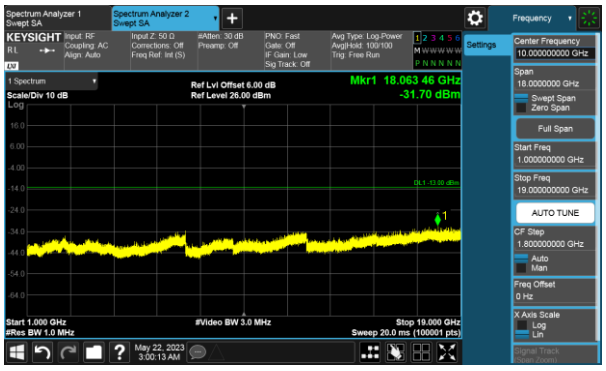
LTE Band 13 QPSK, CH 23182



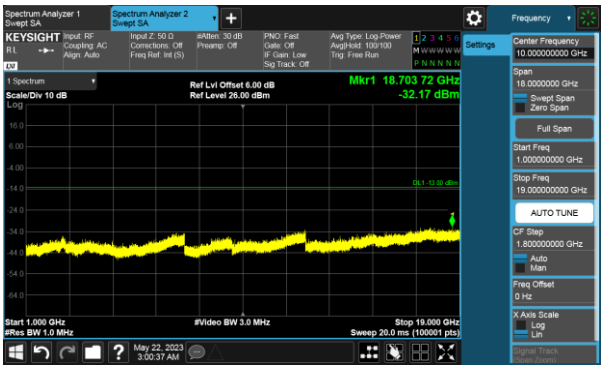
LTE Band 13 QPSK, CH 23230



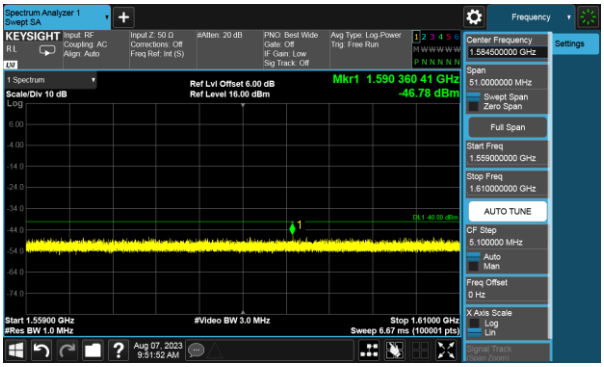
LTE Band 13 QPSK, CH 23182



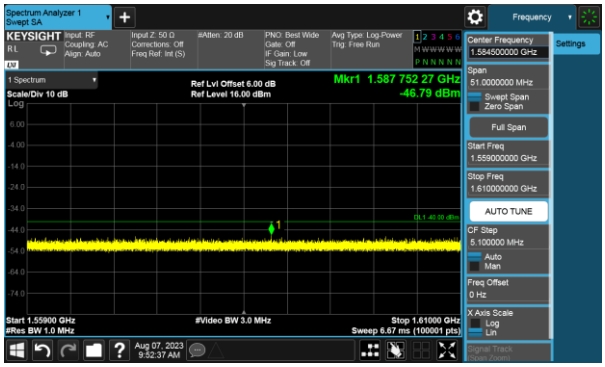
LTE Band 13 QPSK, CH 23230



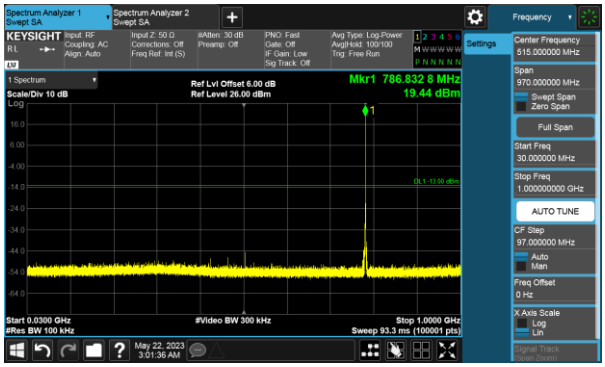
LTE Band 13 QPSK, CH 23182



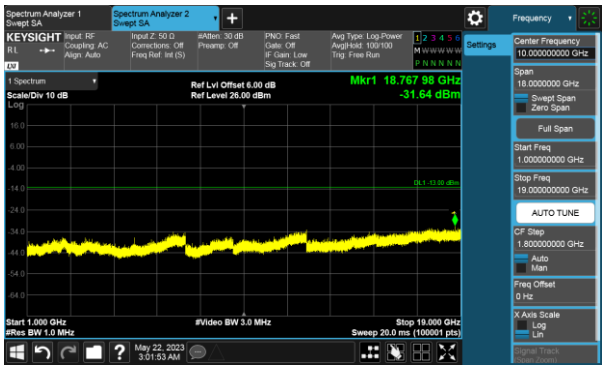
LTE Band 13 QPSK, CH 23230



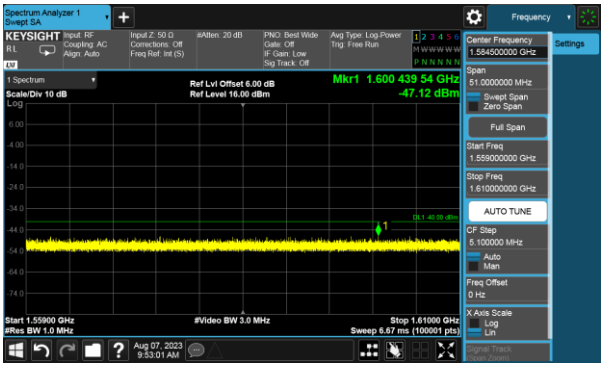
NB-IoT
LTE Band 13 QPSK, CH 23278



LTE Band 13 QPSK, CH 23278



LTE Band 13 QPSK, CH 23278



10. Radiation Emission Test

10.1. Test Limit

For LTE Band 4:
In the FCC 27.53(h)(4):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.

For LTE Band 12:
According to 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.

For LTE Band 13:
According to FCC 27.53(c)(2) for 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.

According to FCC 27.53(f) for operations in the 775-788 MHz, emissions in the band 1559-1610 MHz shall be limited to -70 dBW/MHz. The limit of emissions is equal to -40 dBm.

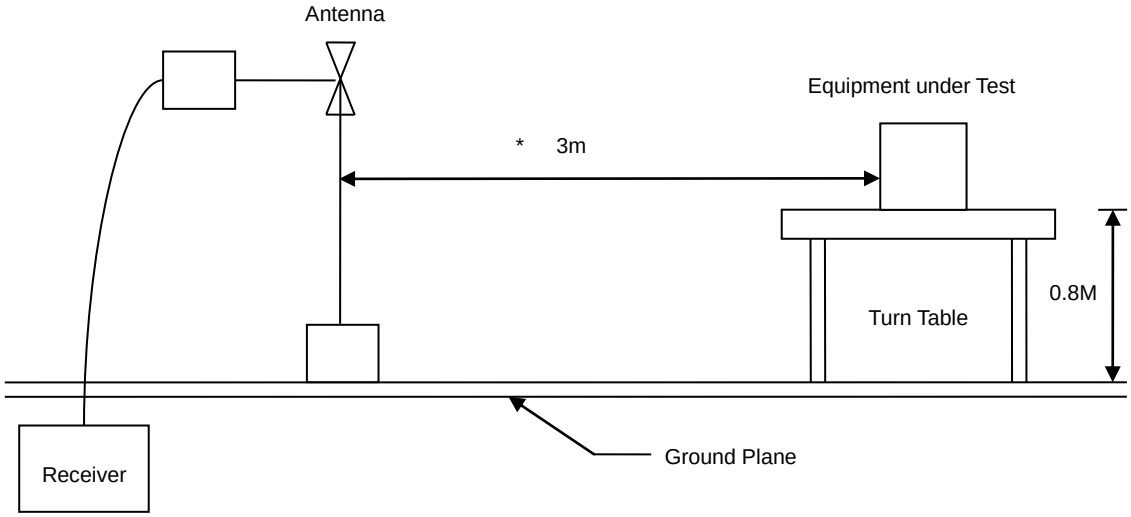
10.2. Test Procedure

a. The EUT was set up for the maximum power with wwan link data modulation. The power was measured with Spectrum Analyzer.
b. E.I.R.P power measurement. In the semi-anechoic chamber, EUT placed on the 0.8m height of Turn Table, rotated the table around 360 degrees to search the maximum radiation power and receiver antenna shall be otated vertical and horizontal polarization and moved height from 1m to 4m to find the maximum polar radiated power. The “Read Value” is the spectrum reading the maximum power value.
c. The substitution antenna (Note:1 & 2) is substituted for EUT at the same position and signals generator export the CW signal to the substitution antenna via a TX cable. Rotated the Turn Table and moved receiving antenna to find the maximum radiation power. Adjust output power level of S.G to get a Value of spectrum reading equal to “Read Value” of step a. Record the power level of S.G.
d. E.I.R.P. = Output power level of S.G - TX cable loss + Antenna gain of substitution horn
e. E.R.P. = E.I.R.P.- 2.15 dB

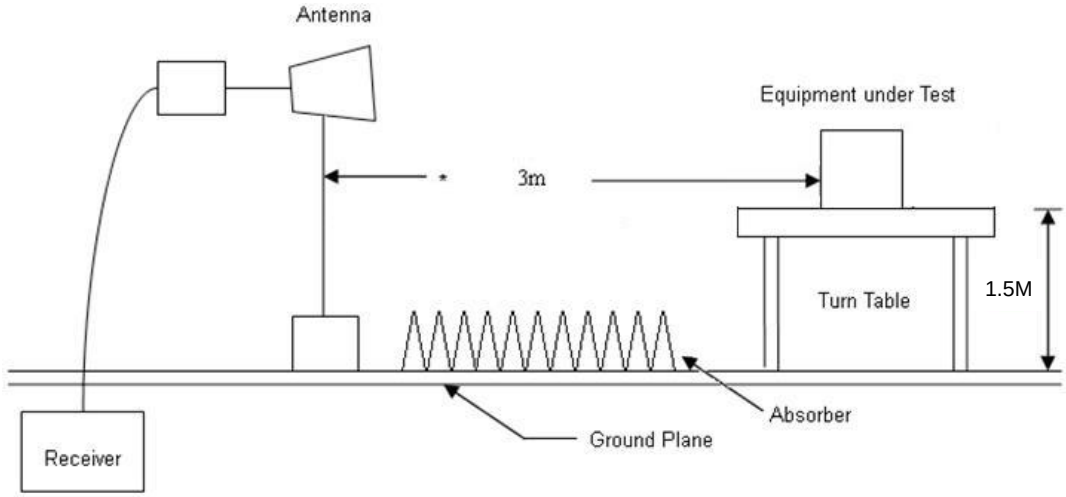
Note: 1. Below 1GHz substituted method test: sleeve dipole antenna to Bi-Log Antenna.
2. Above 1GHz substituted method test: horn antenna to horn antenna.

10.3. Test Setup

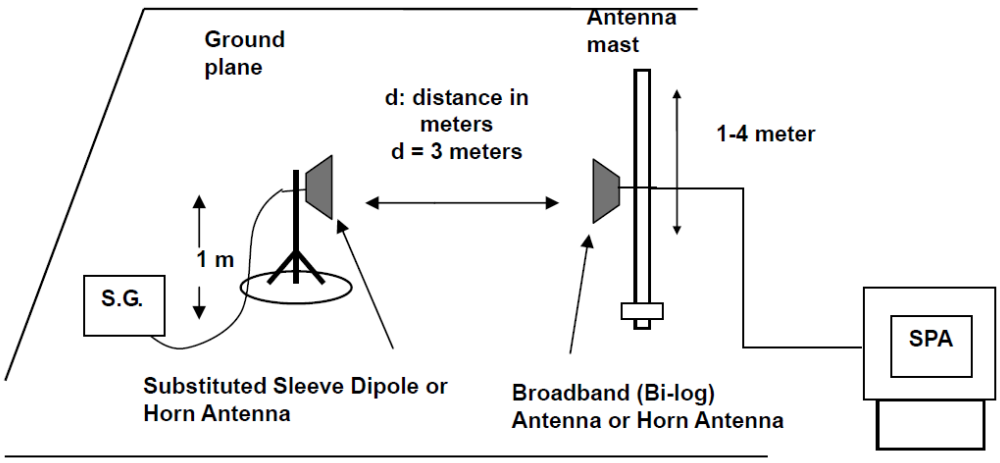
Below 1GHz test setup



Above 1GHz Test Setup

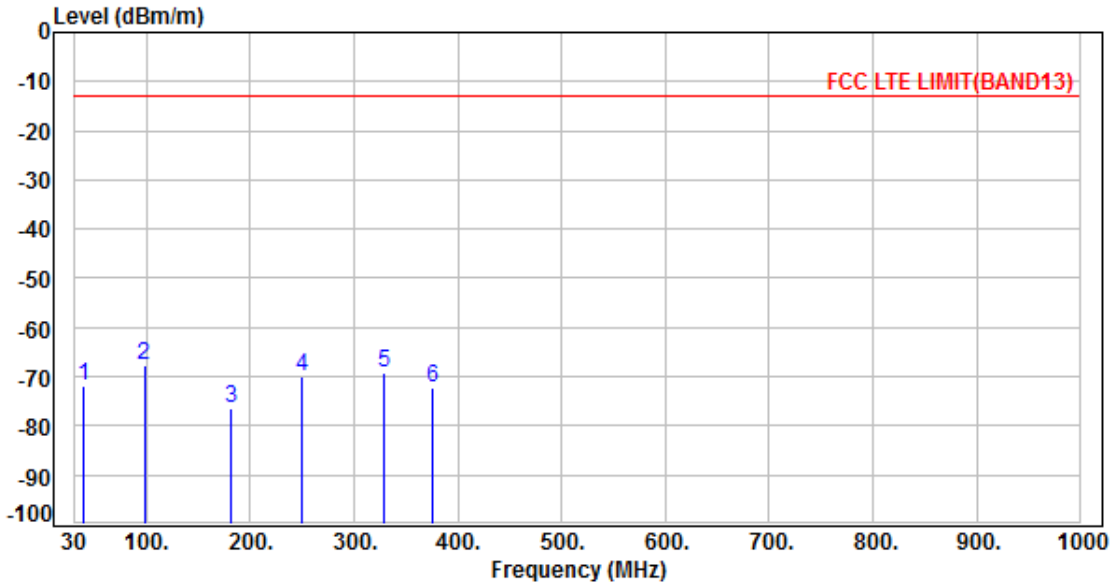


For Substituted Method Test Set-UP



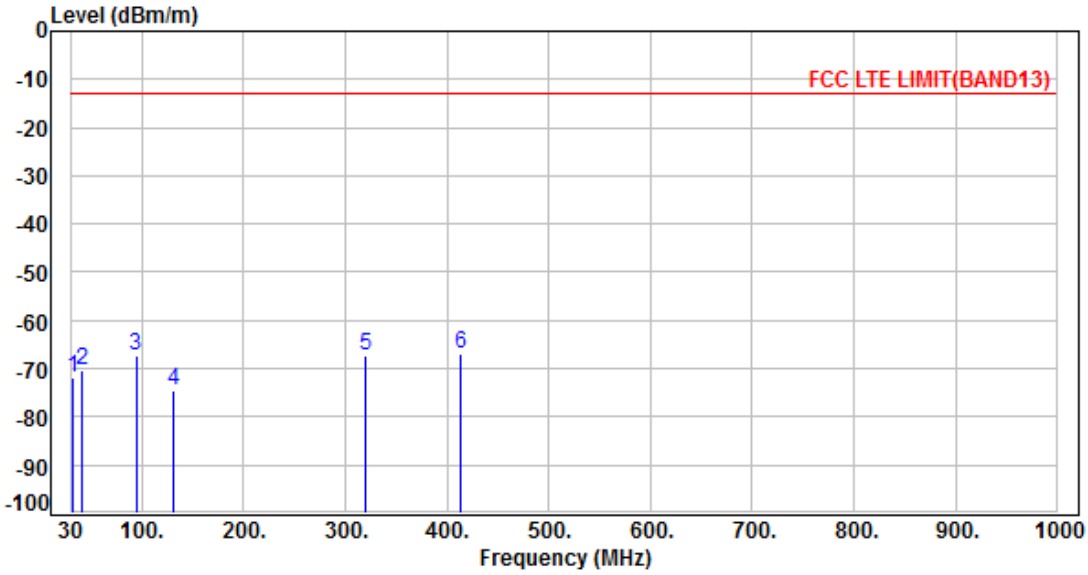
10.4. Test Result and Data (30MHz ~ 1GHz)

Test Mode	Cat M1, Band 13 10MHz, CH 23230	Pol/Phase	VERTICAL
Power	AC 120V/60Hz		



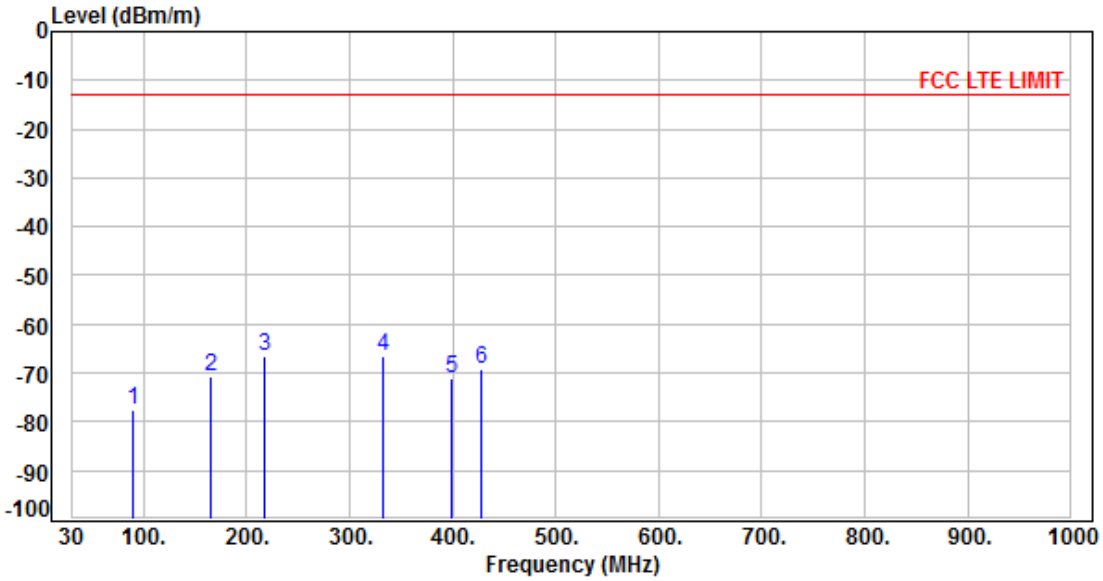
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	ERP (dBm)	Limit (dBm)
39.7	-66.78	V	-51.62	1.55	-16.63	-71.95	-13
97.88	61.41	V	-59.74	1.51	-4.17	-67.57	-13
181.32	-73.05	V	-70.77	1.8	-1.79	-76.51	-13
250.19	-69.27	V	-66.27	2.18	0.77	-69.83	-13
328.76	-70.14	V	-65.15	2.33	0.57	-69.06	-13
375.32	-72.45	V	-68.55	2.42	0.69	-72.43	-13

Test Mode	Cat M1, Band 13 10MHz, CH 23230	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



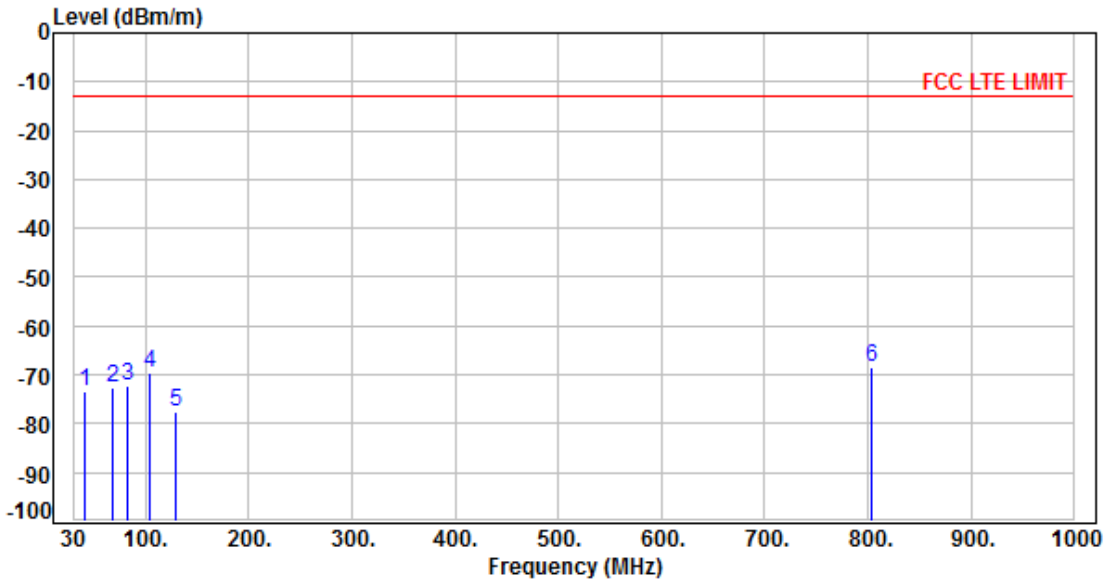
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	ERP (dBm)	Limit (dBm)
32.796	-74.57	H	-51.23	1.28	-17.12	-71.78	-13
40.688	-74.57	H	-50.12	1.64	-16.36	-70.27	-13
94.22	-65.94	H	-59.79	1.5	-4.01	-67.45	-13
131.85	-71.01	H	-65.55	1.77	-5.04	-74.51	-13
319.12	-64.32	H	-63.45	2.29	0.59	-67.3	-13
414.12	-71.19	H	-63.05	2.47	0.87	-66.8	-13

Test Mode	NB-IoT, Band 4, CH 20175	Pol/Phase	VERTICAL
Power	AC 120V/60Hz		



Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
89.17	-70.5	V	-71.37	1.47	-4.55	-77.39	-13
165.8	-66.67	V	-64.65	1.78	-4.18	-70.61	-13
217.21	-64.39	V	-65.6	1.93	1.05	-66.48	-13
332.64	-67.63	V	-64.94	2.34	0.65	-66.63	-13
399.57	-70.59	V	-69.53	2.42	0.84	-71.11	-13
427.7	-69.2	V	-67.96	2.51	1.43	-69.04	-13

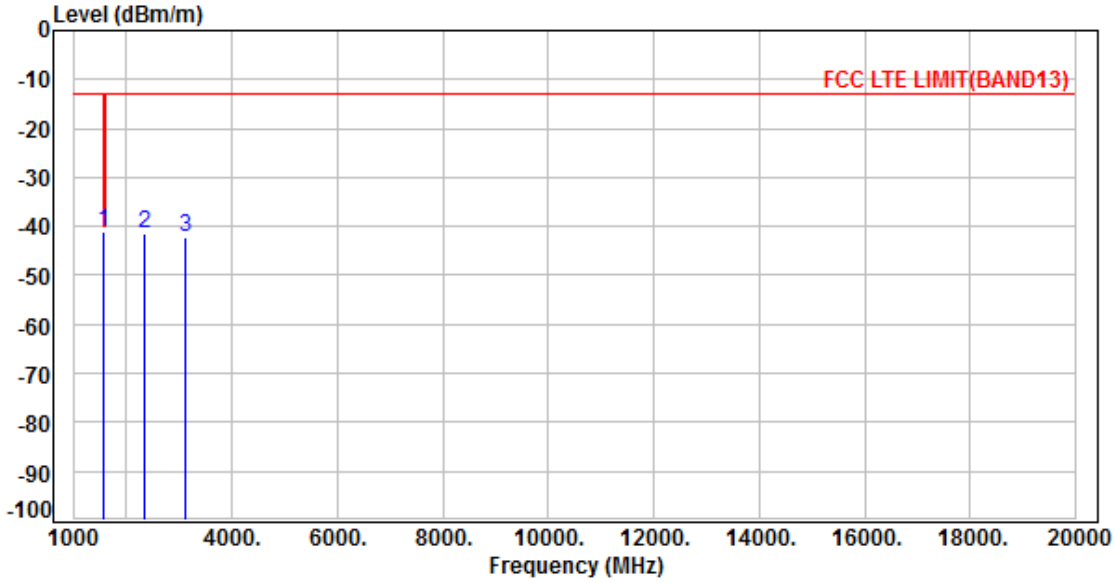
Test Mode	NB-IoT, Band 4, CH 20175	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
40.68	-77.58	H	-55.4	1.63	-16.37	-73.4	-13
68.44	-73.32	H	-60.72	1.22	-10.68	-72.62	-13
82.38	-71.15	H	-65.29	1.35	-5.7	-72.34	-13
104.2	-67.88	H	-63.12	1.56	-4.75	-69.43	-13
128.94	-74.37	H	-71.08	1.71	-4.88	-77.67	-13
804.22	-82.55	H	-65.4	3.33	0.23	-68.5	-13

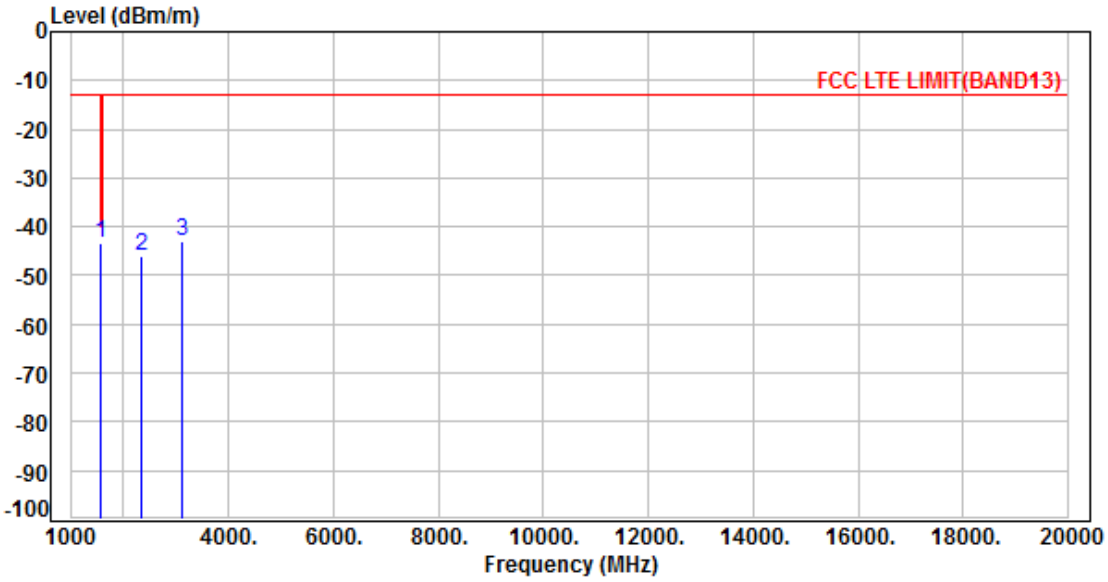
10.5. Test Result and Data (1GHz ~ 20GHz)

Test Mode	Cat M1, Band 13 10MHz, CH 23230	Pol/Phase	VERTICAL
Power	AC 120V/60Hz		



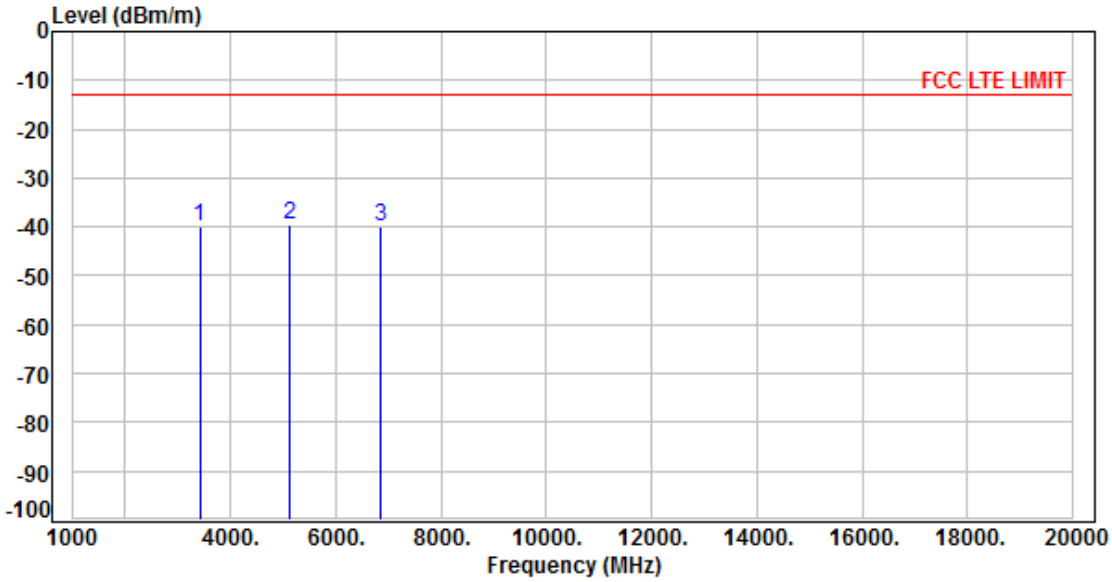
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	ERP (dBm)	Limit (dBm)
1564	-46.19	V	-43.52	4.36	8.8	-41.23	-13
2346	-51.05	V	-43.48	5.36	9.4	-41.59	-13
3128	-54.96	V	-43.24	6.2	9.44	-42.15	-13

Test Mode	Cat M1, Band 13 10MHz, CH 23230	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



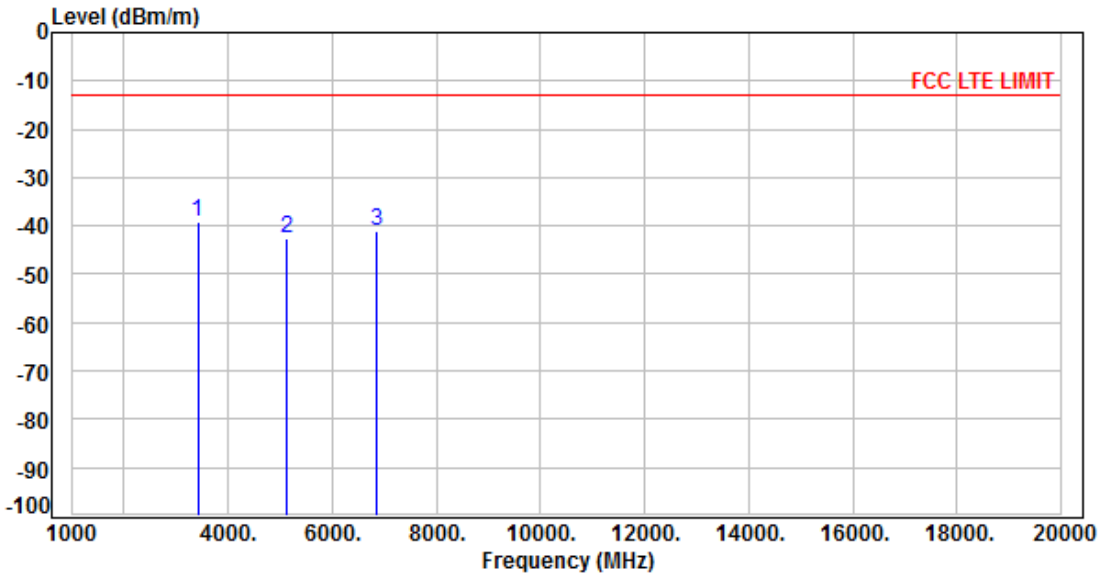
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	ERP (dBm)	Limit (dBm)
1564	-48.25	H	-45.46	4.36	8.8	-43.17	-13
2346	-55.25	H	-47.77	5.36	9.4	-45.88	-13
3128	-55.54	H	-43.95	6.2	9.44	-42.86	-13

Test Mode	NB-IoT, Band 4, CH 19952	Pol/Phase	VERTICAL
Power	AC 120V/60Hz		



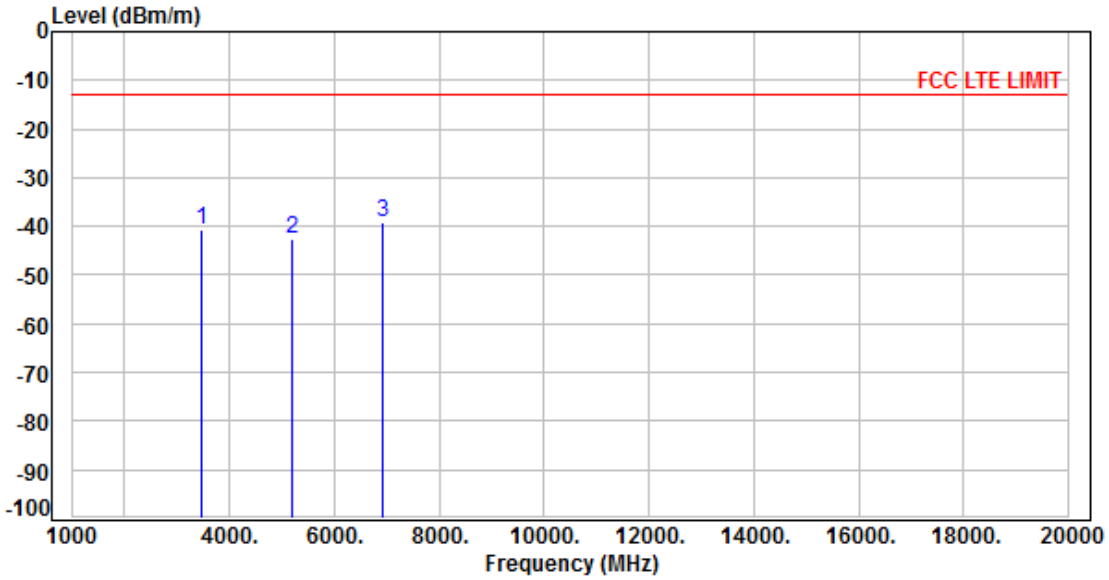
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3420.4	-53.92	V	-43.04	6.47	9.68	-39.83	-13
5130.6	-58.24	V	-42.25	8.04	10.7	-39.59	-13
6840.8	-59.67	V	-42.12	9.3	11.58	-39.84	-13

Test Mode	NB-IoT, Band 4, CH 19952	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



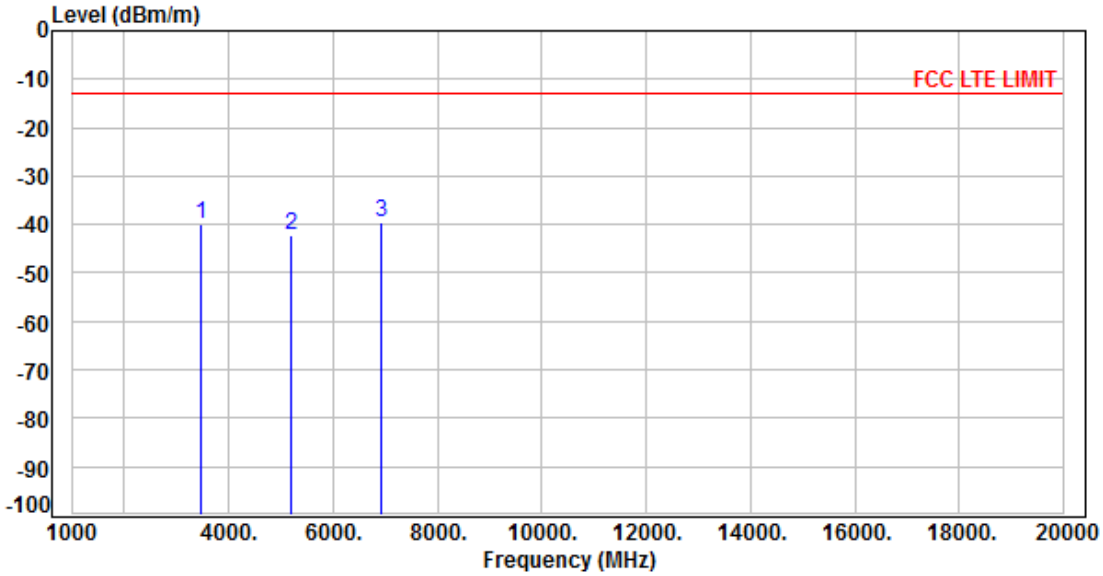
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3420.4	-53.04	H	-42.4	6.47	9.68	-39.19	-13
5130.6	-61.33	H	-45.28	8.04	10.7	-42.62	-13
6840.8	-61.21	H	-43.19	9.6	11.58	-41.21	-13

Test Mode	NB-IoT, Band 4, CH 20175	Pol/Phase	VERTICAL
Power	AC 120V/60Hz		



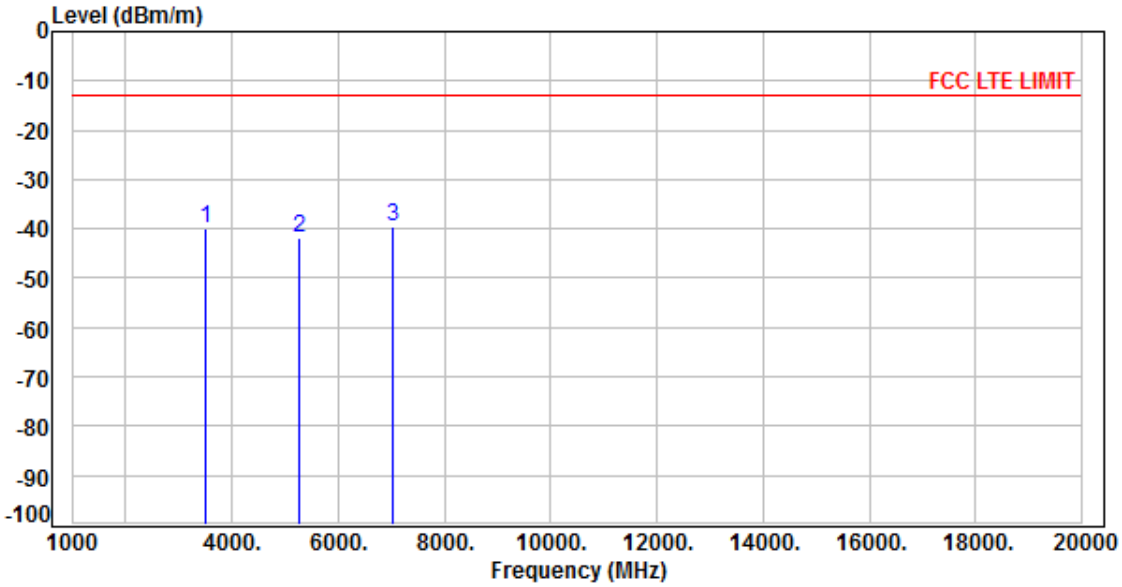
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3465	-54.84	V	-43.87	6.51	9.83	-40.55	-13
5197.5	-61.3	V	-45.16	8.11	10.7	-42.57	-13
6930	-58.87	V	-41.5	9.35	11.6	-39.25	-13

Test Mode	NB-IoT, Band 4, CH 20175	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



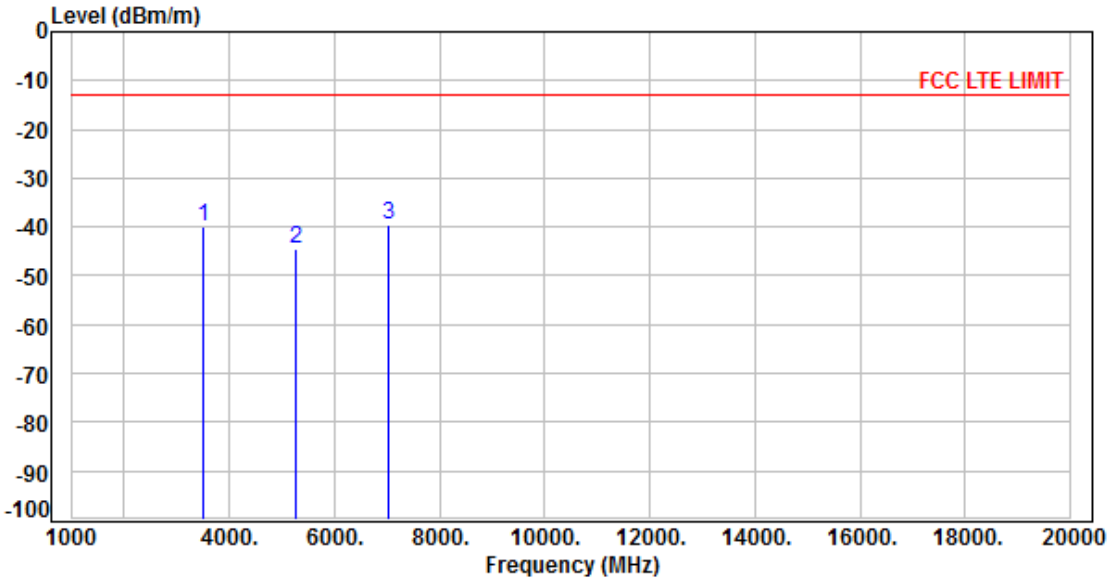
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3465	-53.8	H	-43.08	6.51	9.83	-39.76	-13
5197.5	-61.08	H	-44.86	8.11	10.7	-42.27	-13
6930	-59.59	H	-41.88	9.35	11.6	-39.63	-13

Test Mode	NB-IoT, Band 4, CH 20398	Pol/Phase	VERTICAL
Power	AC 120V/60Hz		



Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3509.8	-54.25	V	-43.13	6.55	9.9	-39.78	-13
5264.7	-60.74	V	-44.44	8.17	10.7	-41.91	-13
7019.6	-59	V	-41.75	9.4	11.7	-39.45	-13

Test Mode	NB-IoT, Band 4, CH 20398	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3509.8	-53.97	H	-43.1	6.55	9.9	-39.75	-13
5264.7	-63.23	H	-46.85	8.17	10.7	-44.32	-13
7019.6	-59.28	H	-41.78	9.4	11.7	-39.48	-13

11. Frequency Stability (Temperature & Voltage Variation) Test

11.1. Test Limit

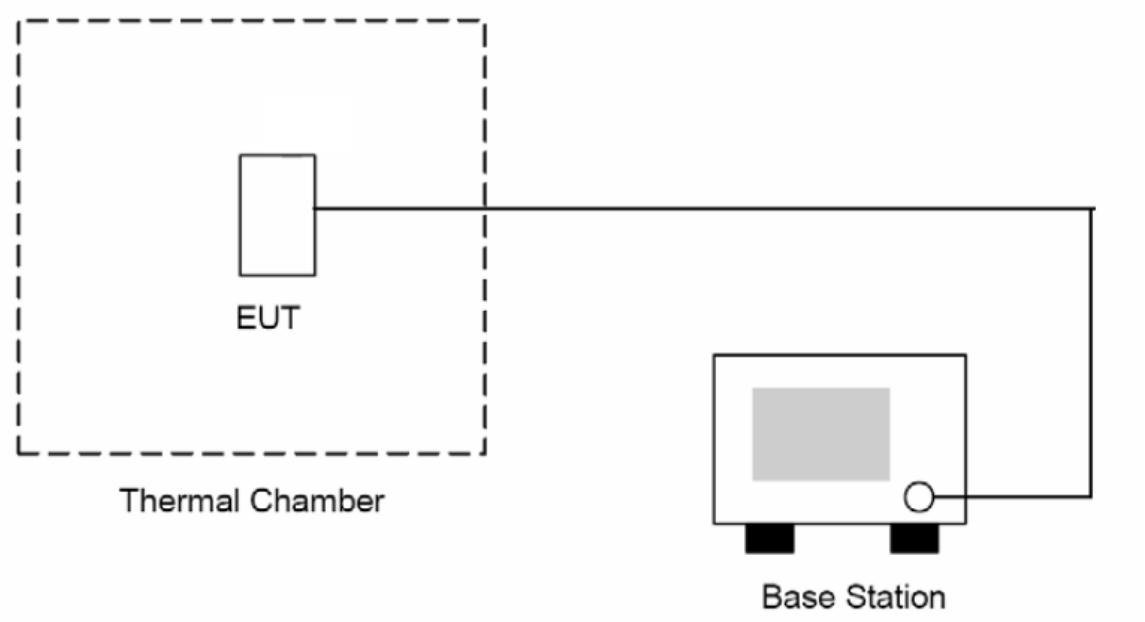
Mobile:
The frequency stability shall be measured by variation of ambient temperature and variation of primary supply voltage to ensure that the fundamental emission stays within the authorized frequency block. The frequency stability of the transmitter shall be maintained within ±0.00025% (±2.5ppm) of the center frequency.

Fixed or Base:
The frequency stability shall be measured by variation of ambient temperature and variation of primary supply voltage to ensure that the fundamental emission stays within the authorized frequency block. The frequency stability of the ransmitter shall be maintained within ±0.00015% (±1.5ppm) of the center frequency.

11.2. Test Procedure

1. The EUT and test equipment were set up as shown on the following section.
2. With all power removed, the temperature was decreased to -30℃ and permitted to stabilize for three hours. Power was applied and the maximum change in frequency was note within one minute.
3. With power OFF, the temperature was raised in 10℃ steps. The sample was permitted to stabilize at each step for at least one-half hour. Power was applied and the maximum frequency change was noted within one minute.
4. The EUT was placed in a temperature chamber at 25 ±5℃ and connected as the following section.
5. The power supply voltage to the EUT was varied from BEP to 115% of the nominal value measured at the input to the EUT.
6. The temperature tests were performed for the worst case.
7. Test data was recorded.

11.3. Test Setup



11.4. Test Result and Data

Cat M1

LTE Band 4 QPSK 20M middle channel

Frequency Stability under Temperature				
Temperature Interval (°C)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
50	1732.5	1.22	0.001	2.5
40	1732.5	0.29	0.000	2.5
30	1732.5	0.21	0.000	2.5
20	1732.5	3.61	0.002	2.5
10	1732.5	2.54	0.001	2.5
0	1732.5	1.23	0.001	2.5
-10	1732.5	-0.18	0.000	2.5
-20	1732.5	-0.03	0.000	2.5
-30	1732.5	-2.36	-0.001	2.5

LTE Band 4 QPSK 20M middle channel

Frequency Stability under Voltage at 20°C				
DC Voltage (V)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
138	1732.5	3.61	0.002	2.5
120	1732.5	2.54	0.001	2.5
102	1732.5	1.19	0.001	2.5

Cat M1

LTE Band 12 QPSK 10M middle channel

Frequency Stability under Temperature				
Temperature Interval (°C)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
50	707.5	1.66	0.002	2.5
40	707.5	2.88	0.004	2.5
30	707.5	-0.26	0.000	2.5
20	707.5	-1.32	-0.002	2.5
10	707.5	-2.06	-0.003	2.5
0	707.5	-3.17	-0.004	2.5
-10	707.5	2.51	0.004	2.5
-20	707.5	0.18	0.000	2.5
-30	707.5	-0.79	-0.001	2.5

LTE Band 12 QPSK 10M middle channel

Frequency Stability under Voltage at 20°C				
DC Voltage (V)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
138	707.5	0.31	0.000	2.5
120	707.5	3.58	0.005	2.5
102	707.5	1.26	0.002	2.5

Cat M1

LTE Band 13 QPSK 10M middle channel

Frequency Stability under Temperature				
Temperature Interval (°C)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
50	782	-3.55	-0.005	2.5
40	782	0.09	0.000	2.5
30	782	-2.57	-0.003	2.5
20	782	-1.51	-0.002	2.5
10	782	0.63	0.001	2.5
0	782	2.34	0.003	2.5
-10	782	1.29	0.002	2.5
-20	782	0.56	0.001	2.5
-30	782	-0.89	-0.001	2.5

LTE Band 13 QPSK 10M middle channel

Frequency Stability under Voltage at 20°C				
DC Voltage (V)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
138	782	3.64	0.005	2.5
120	782	2.57	0.003	2.5
102	782	1.44	0.002	2.5

NB-IoT

Band 4 QPSK middle channel

Frequency Stability under Temperature				
Temperature Interval (°C)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
50	1732.5	2.98	0.002	2.5
40	1732.5	3.15	0.002	2.5
30	1732.5	3.22	0.002	2.5
20	1732.5	1.79	0.001	2.5
10	1732.5	1.54	0.001	2.5
0	1732.5	0.11	0.000	2.5
-10	1732.5	0.18	0.000	2.5
-20	1732.5	-1.22	-0.001	2.5
-30	1732.5	-1.64	-0.001	2.5

Band 4 QPSK middle channel

Frequency Stability under Voltage at 20°C				
DC Voltage (V)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
138	1732.5	0.38	0.000	2.5
120	1732.5	0.05	0.000	2.5
102	1732.5	-1.25	-0.001	2.5

NB-IoT

Band 12 QPSK middle channel

Frequency Stability under Temperature				
Temperature Interval (°C)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
50	707.5	1.44	0.002	2.5
40	707.5	0.26	0.000	2.5
30	707.5	0.09	0.000	2.5
20	707.5	-1.58	-0.002	2.5
10	707.5	-0.36	-0.001	2.5
0	707.5	-0.09	0.000	2.5
-10	707.5	1.69	0.002	2.5
-20	707.5	3.54	0.005	2.5
-30	707.5	3.31	0.005	2.5

Band 12 QPSK middle channel

Frequency Stability under Voltage at 20°C				
DC Voltage (V)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
138	707.5	2.61	0.004	2.5
120	707.5	0.23	0.000	2.5
102	707.5	0.01	0.000	2.5

NB-IoT

Band 13 QPSK middle channel

Frequency Stability under Temperature				
Temperature Interval (°C)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
50	782	1.73	0.002	2.5
40	782	3.31	0.004	2.5
30	782	2.26	0.003	2.5
20	782	0.25	0.000	2.5
10	782	-0.16	0.000	2.5
0	782	-0.92	-0.001	2.5
-10	782	-3.54	-0.005	2.5
-20	782	-3.12	-0.004	2.5
-30	782	-2.56	-0.003	2.5

Band 13 QPSK middle channel

Frequency Stability under Voltage at 20°C				
DC Voltage (V)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
138	782	1.24	0.002	2.5
120	782	2.55	0.003	2.5
102	782	3.16	0.004	2.5