8. Band Edge

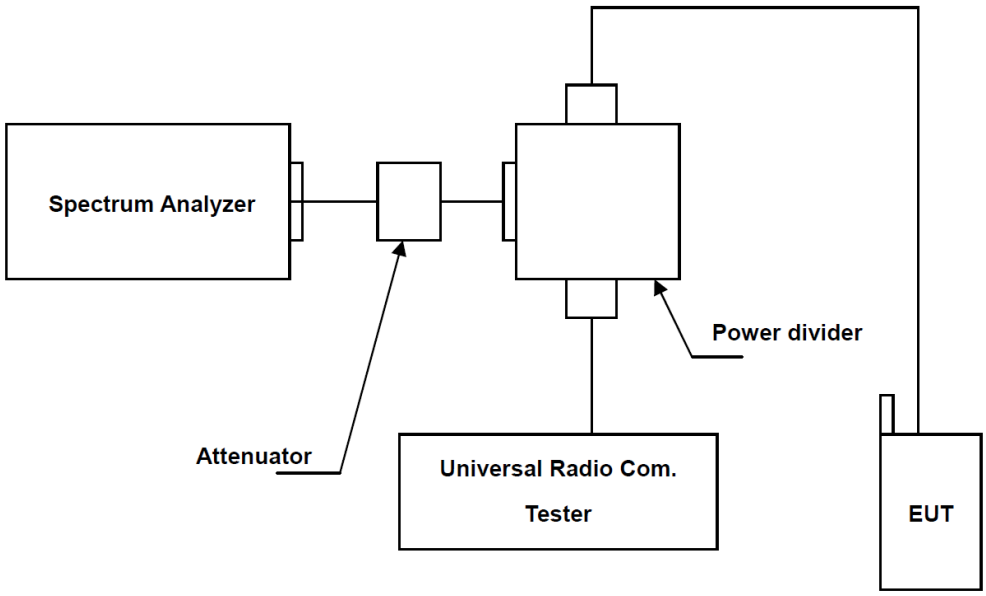
8.1. Test Limit

§24.238(a)
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 + 10log(P) dB.

8.2. 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.
b. The band edge measurement used the power splitter via EUT RF power connector between simulation base station and spectrum analyzer. This splitter loss and cable loss are the worst loss in the transmitted path track.
c. The center frequency of spectrum is the band edge frequency. RB of the resolution bandwidth of at least one percent of the emission bandwidth.
d. Record the max trace plot into the test report.

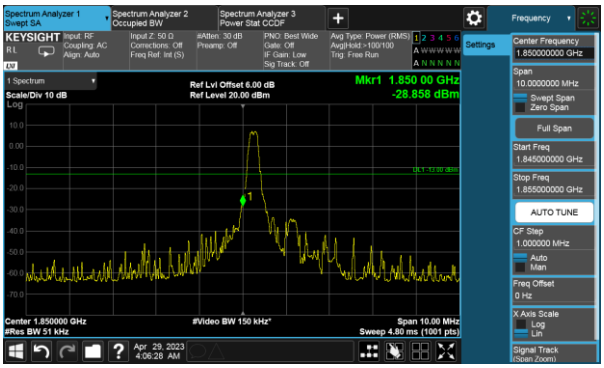
8.3. Test Setup



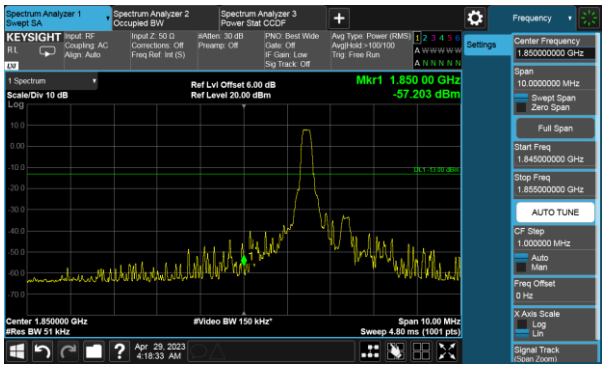
8.4. Test Result and Data

Cat M1

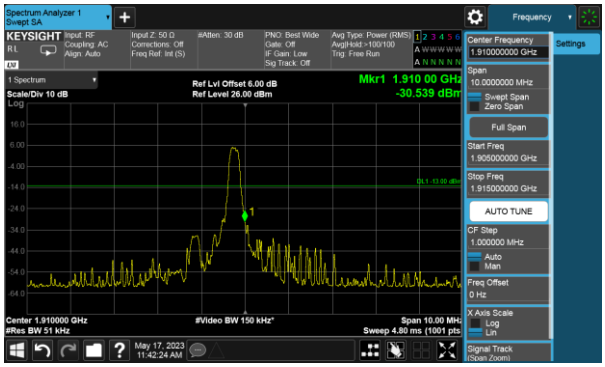
LTE Band 2 QPSK 1.4MHz, CH 18607



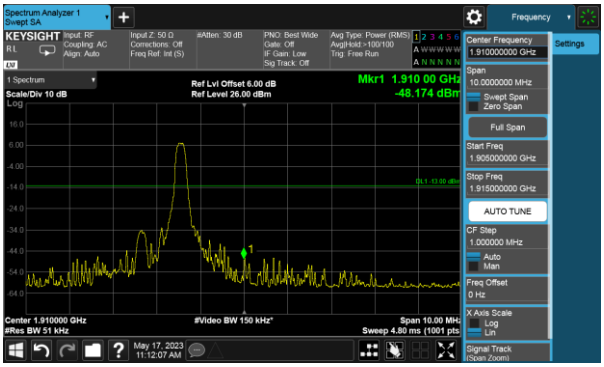
LTE Band 2 QPSK 20MHz, CH 18700



LTE Band 2 QPSK 1.4MHz, CH 19193

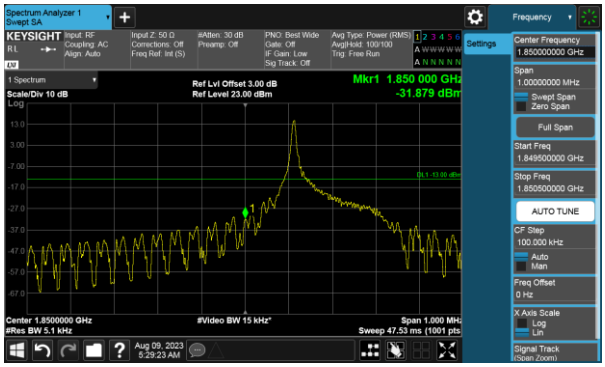


LTE Band 2 QPSK 20MHz, CH 19100

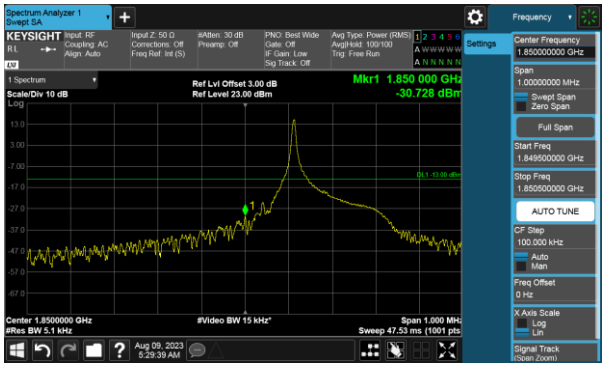


NB-IoT

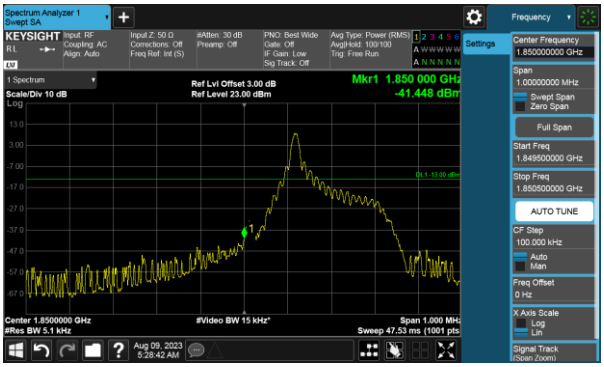
LTE Band 2 QPSK 3.75KHz 1@0 CH 18602



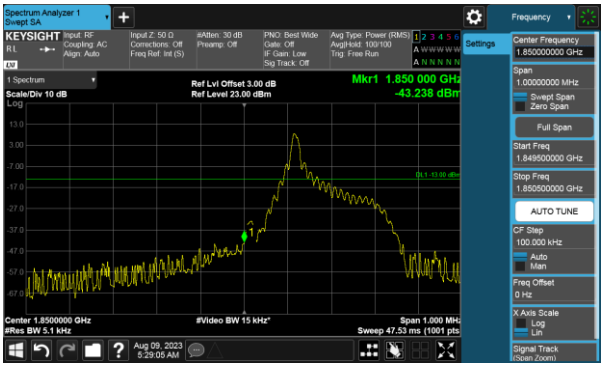
LTE Band 2 BPSK 3.75KHz 1@0 CH 18602



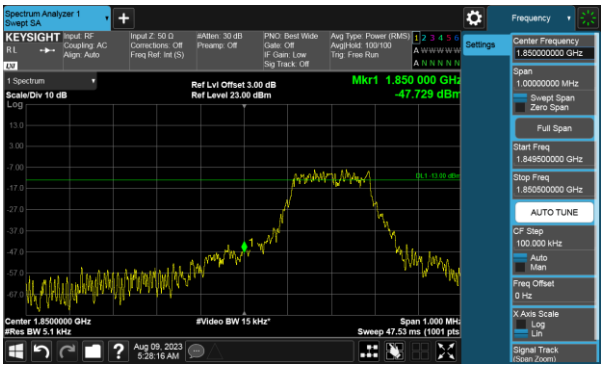
LTE Band 2 QPSK 15KHz 1@0 CH 18602



LTE Band 2 BPSK 15KHz 1@0 CH 18602

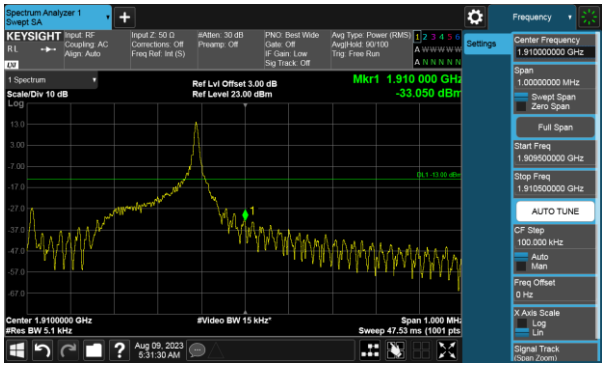


LTE Band 2 QPSK 15KHz 12@0 CH 18602

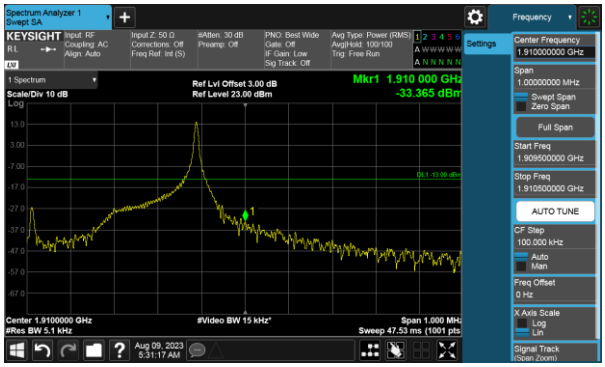


NB-IoT

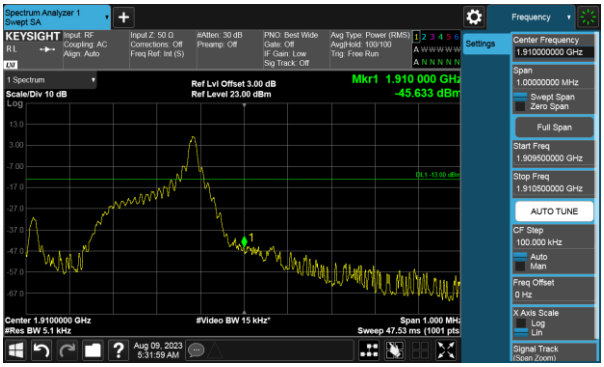
LTE Band 2 QPSK 3.75KHz 1@47 CH 19198



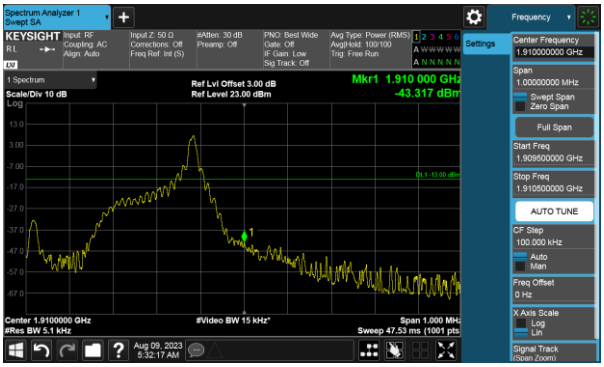
LTE Band 2 BPSK 3.75KHz 1@47 CH 19198



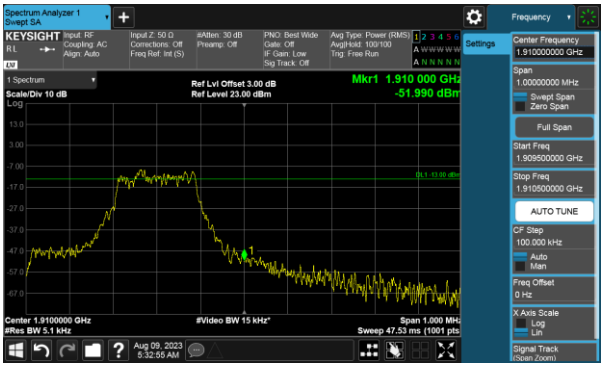
LTE Band 2 QPSK 15KHz 1@11 CH 19198



LTE Band 2 BPSK 15KHz 1@11 CH 19198



LTE Band 2 QPSK 15KHz 12@0 CH 19198



9. Conducted Spurious Emission Test

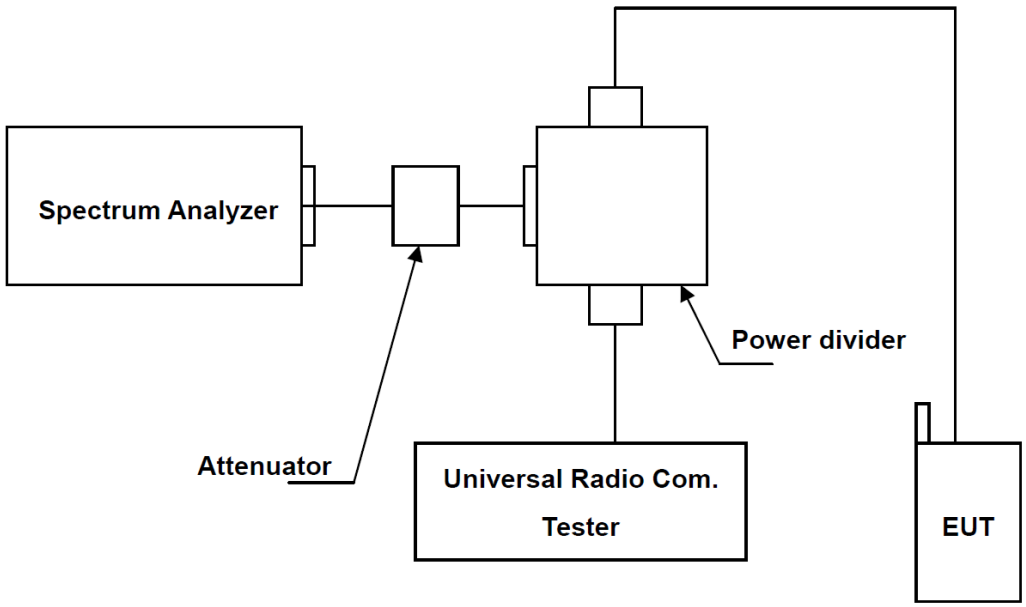
9.1. Test Limit

The power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) by at least 43 +10 log10(P) dB. The limit of emission equal to -13dBm

9.2. Test Procedures

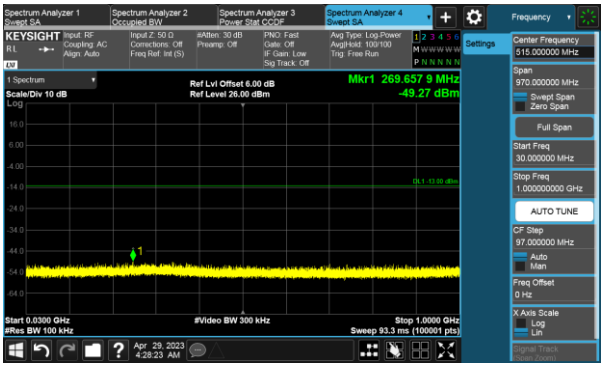
a. The EUT was set up for the maximum peak power with WWAN link data modulation. The power was measured with Spectrum Analyzer.
b. The conducted spurious emission used the power splitter via EUT RF power connector between simulation base station and spectrum analyzer.
c. When the spectrum scanned from 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

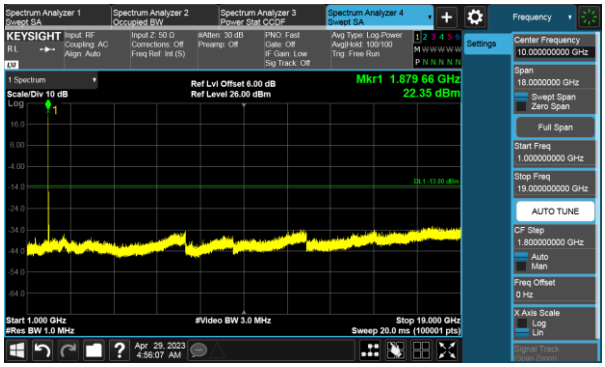


9.4. Test Result and Data

Cat M1
LTE Band 2 QPSK 1.4MHz, CH 18900

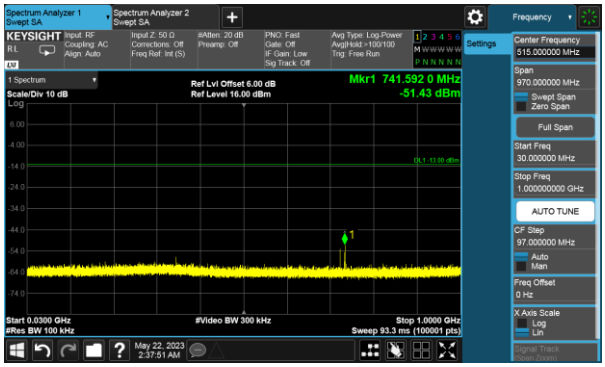


LTE Band 2 QPSK 1.4MHz, CH 18900

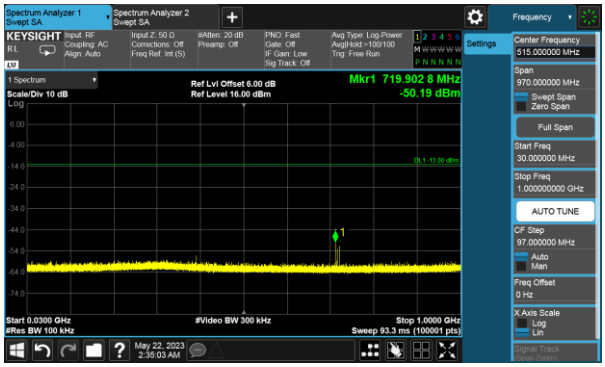


NB-IoT

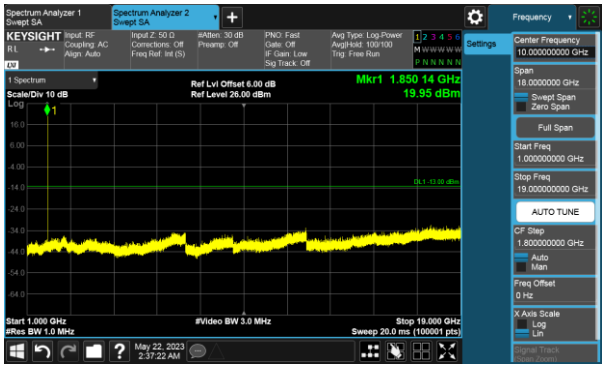
LTE Band 2 QPSK, CH 18601



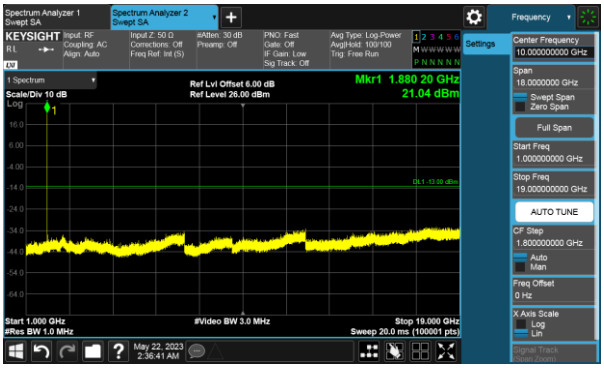
LTE Band 2 QPSK, CH 18900



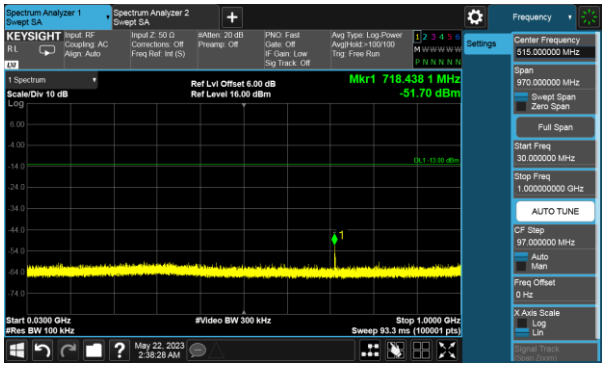
LTE Band 2 QPSK, CH 18601



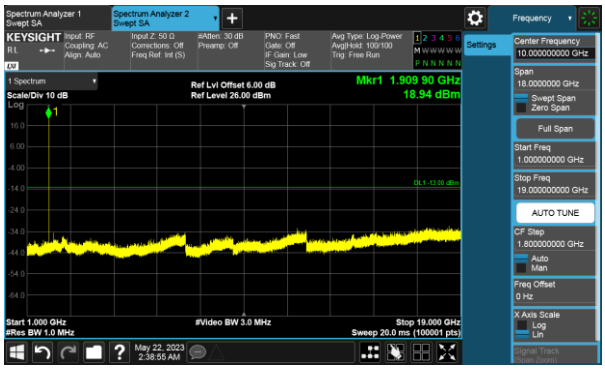
LTE Band 2 QPSK, CH 18900



NB-IoT
LTE Band 2 QPSK, CH 19198



LTE Band 2 QPSK, CH 19198



10. Radiation Emission Test

10.1. Test Limit

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 + 10log(P) dB.

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. All measurements were done at 3 channels (low, middle and high operational frequency range).

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

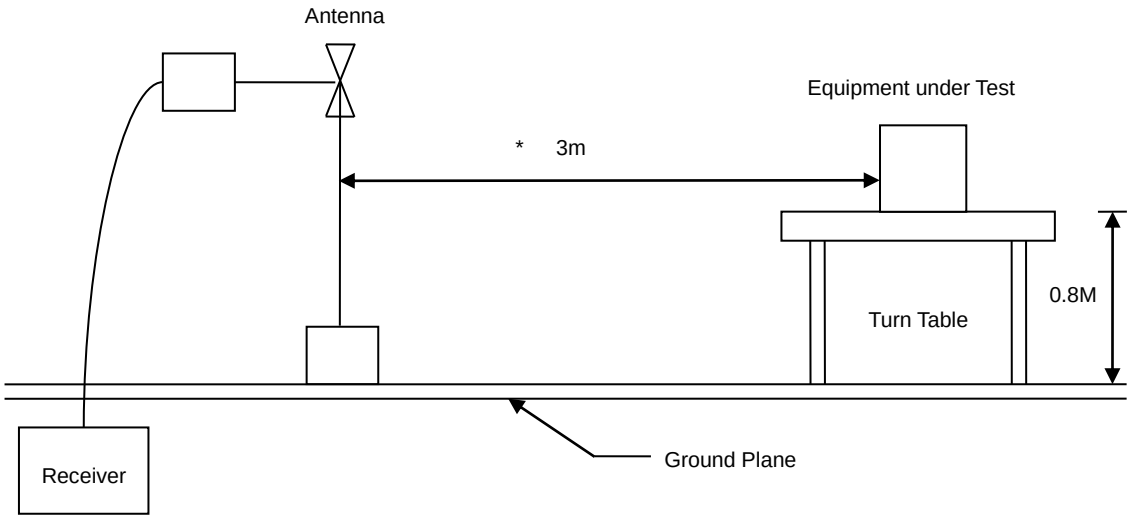
e. E.R.P. = E.I.R.P.- 2.15 dB

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

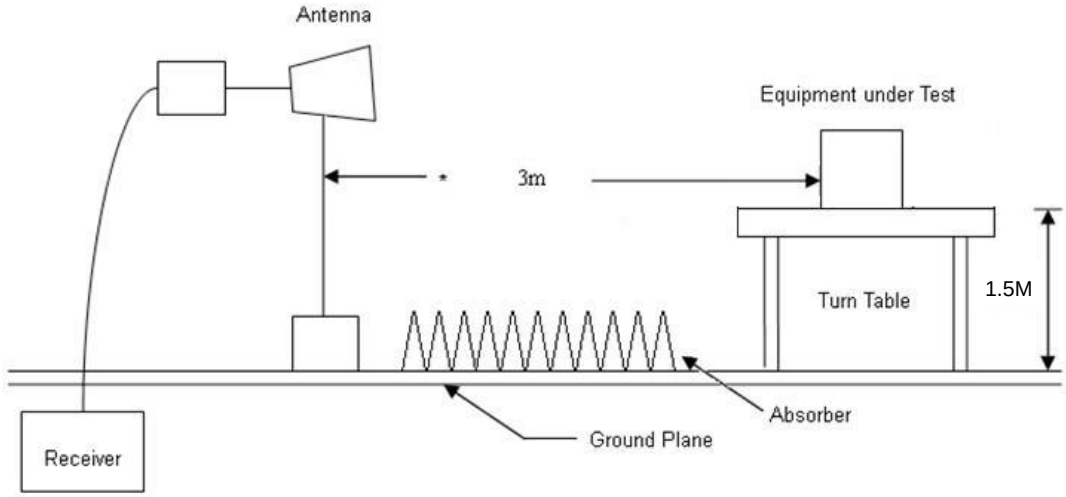
2. Above 1GHz substituted method test: horn antenna to horn antenna.

10.3. Test Setup

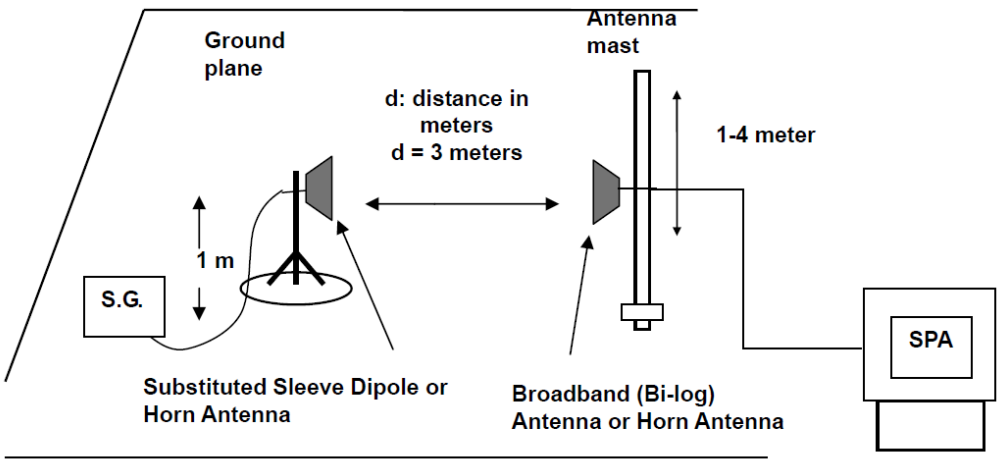
Below 1GHz test setup



Above 1GHz Test Setup

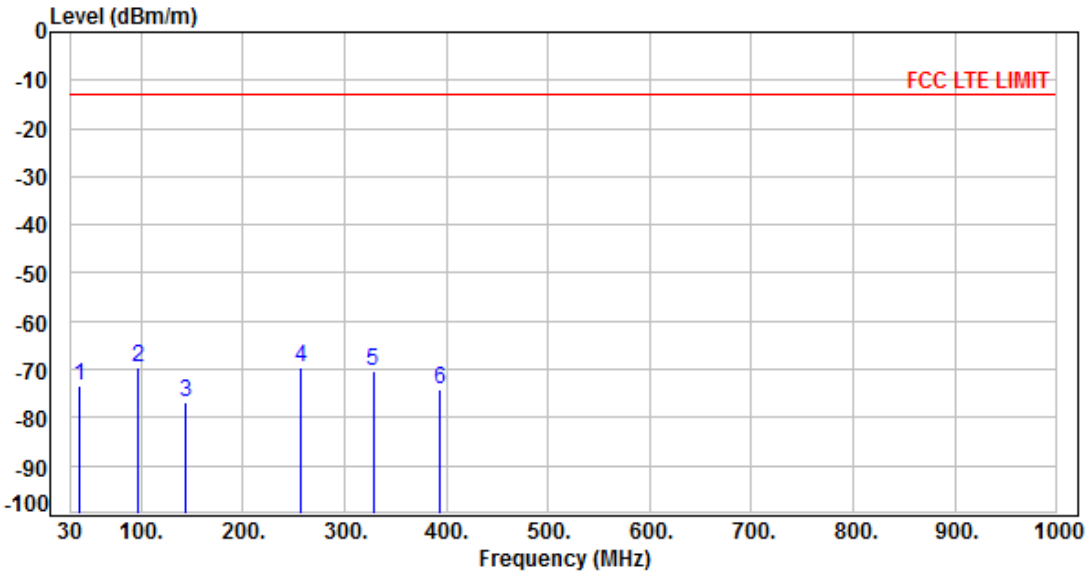


For Substituted Method Test Set-UP



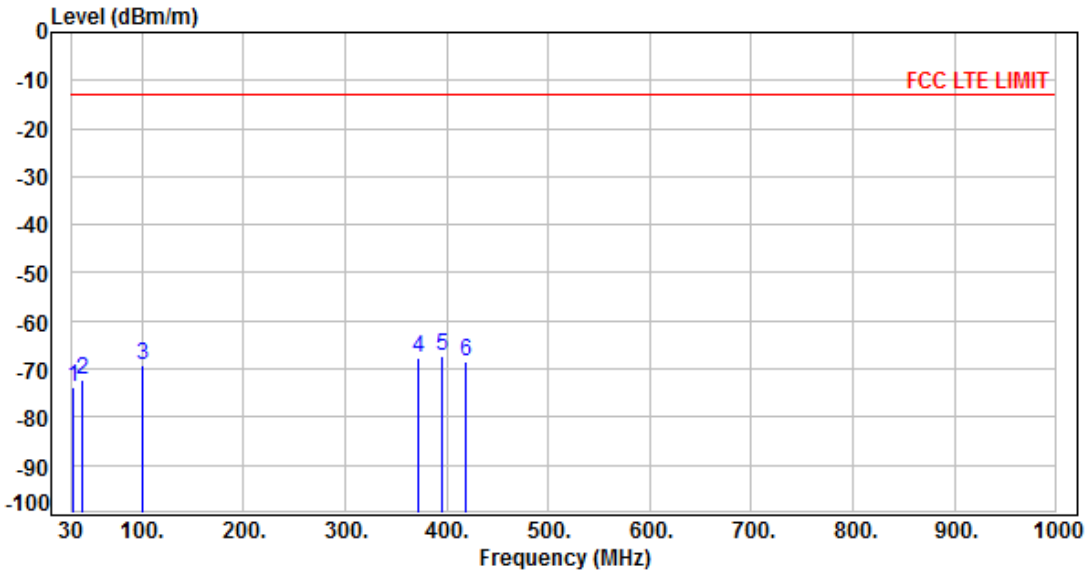
10.4. Test Result and Data (30MHz ~ 1GHz)

Test Mode	Cat M1, Band 2 1.4MHz, CH 19193	Pol/Phase	VERTICAL
Power	AC 120V/60Hz		



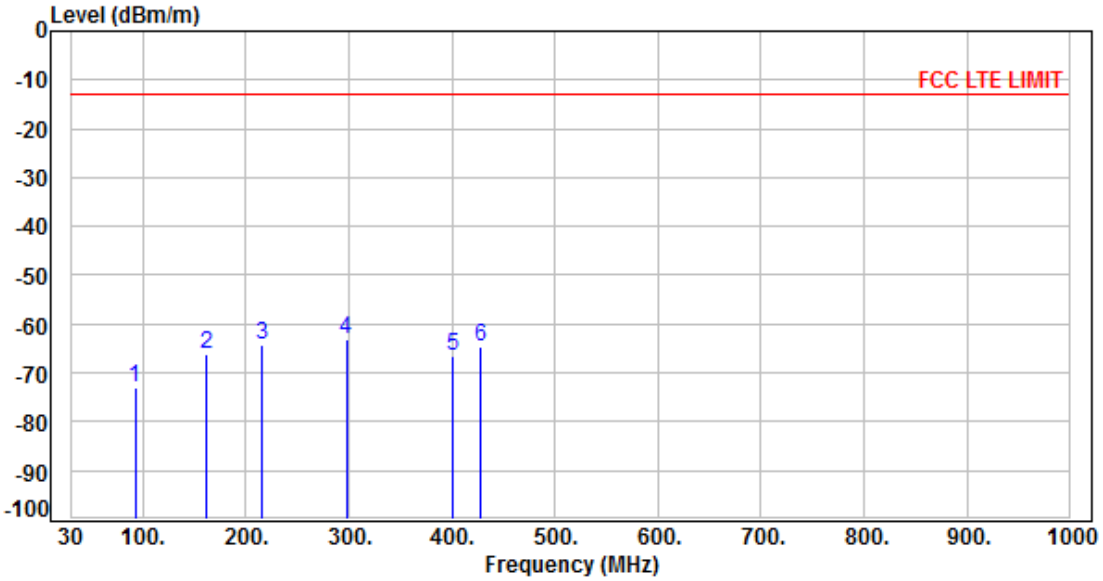
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
39.93	-68.43	V	-55.36	1.56	-16.64	-73.56	-13
96.52	-63.34	V	-63.92	1.51	-4.19	-69.62	-13
144.45	-72.25	V	-69.49	1.97	-5.4	-76.86	-13
256.82	-69.21	V	-68.15	2.15	0.83	-69.47	-13
328	-71.3	V	-68.44	2.33	0.57	-70.2	-13
393.15	-73.68	V	-72.38	2.42	0.74	-74.06	-13

Test Mode	Cat M1, Band 2 1.4MHz, CH 19193	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



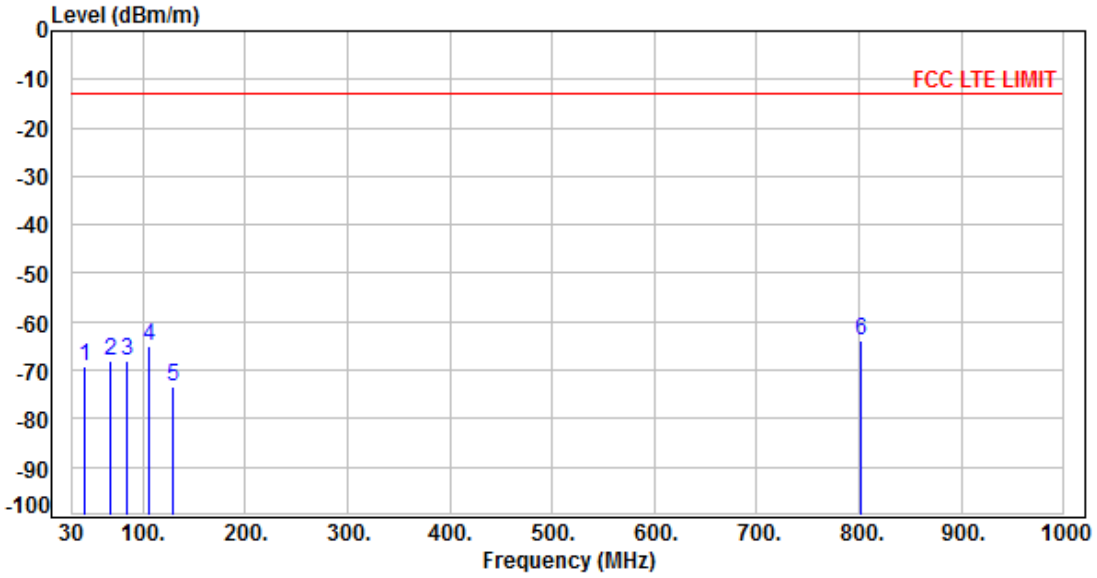
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
32.796	-76.54	H	-55.35	1.28	-17.12	-73.75	-13
40.687	-76.35	H	-54.17	1.64	-16.36	-72.17	-13
100.89	-67.94	H	-63.26	1.53	-4.47	-69.26	-13
371.46	-69.2	H	-65.9	2.41	0.75	-67.56	-13
394.77	-71.05	H	-65.68	2.42	0.74	-67.36	-13
419.35	-72.79	H	-66.53	2.49	0.7	-68.32	-13

Test Mode	NB-IoT, Band 2 5MHz, CH 18600	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)
92.46	-66.35	V	-67.42	1.49	-4.05	-72.96	-13
161.61	-62.04	V	-59.89	1.77	-4.46	-66.12	-13
214.81	-62.15	V	-63.4	1.91	0.96	-64.35	-13
297.42	-64.55	V	-61.36	2.21	0.63	-62.94	-13
400.02	-66.15	V	-65.11	2.42	0.85	-66.68	-13
427.38	-64.75	V	-62.61	2.51	0.53	-64.59	-13

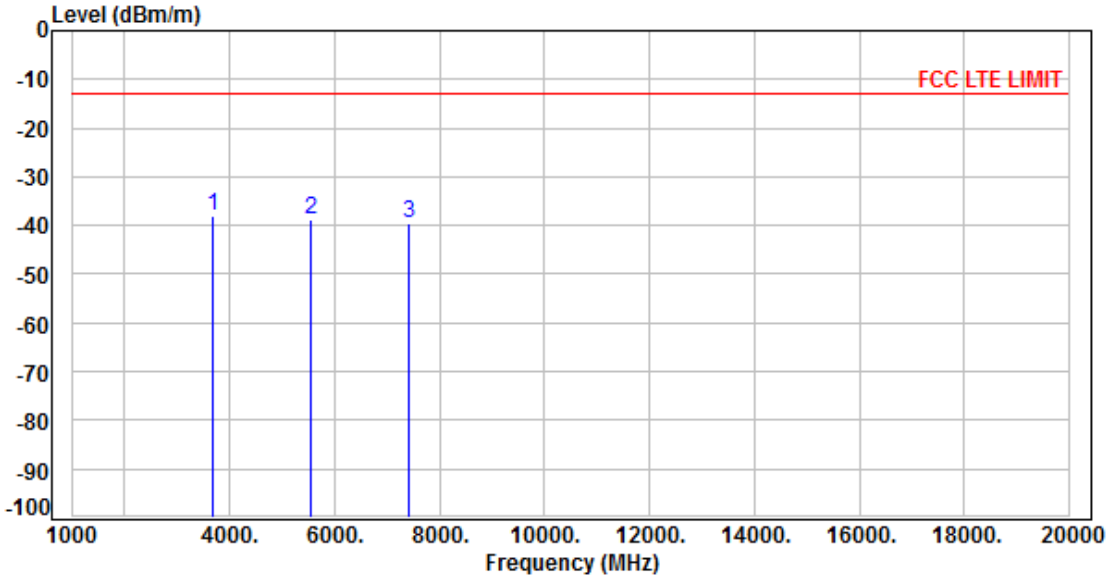
Test Mode	NB-IoT, Band 2 5MHz, CH 18600	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
42.52	-73.35	H	-50.97	1.84	-16.43	-69.24	-13
68.92	-68.7	H	-56.61	1.22	-10.28	-68.11	-13
84.39	-66.65	H	-61.5	1.38	-5.1	-67.98	-13
105.59	-63.27	H	-58.62	1.58	-4.72	-64.92	-13
129.64	-70.08	H	-66.8	1.72	-4.9	-73.42	-13
801.85	-77.87	H	-60.57	3.32	0.15	-63.74	-13

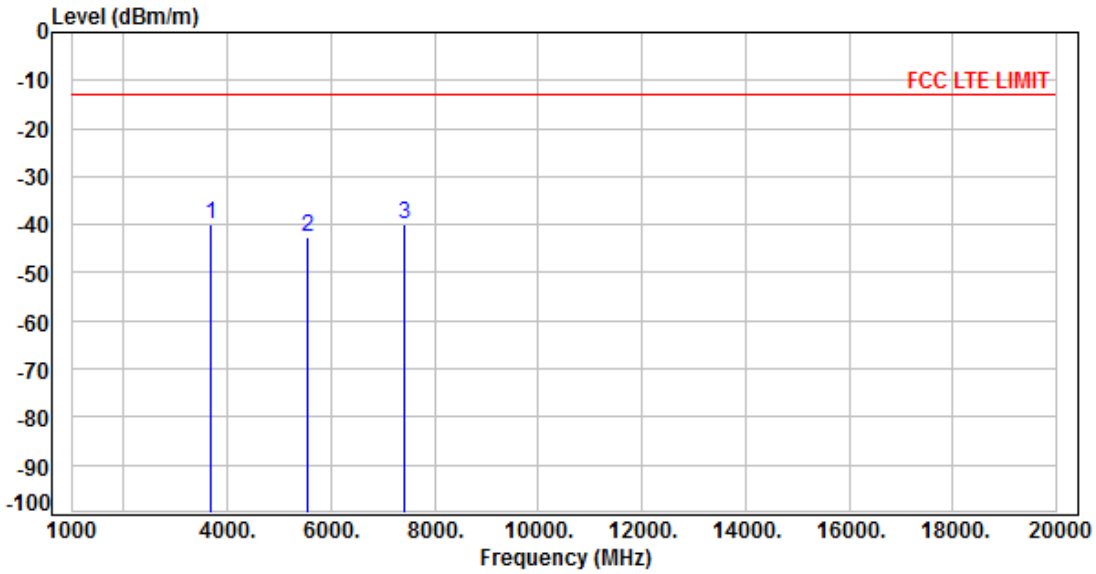
10.5. Test Result and Data (1GHz ~ 20GHz)

Test Mode	Cat M1, Band 2 1.4MHz, CH 18607	Pol/Phase	VERTICAL
Power	AC 120V/60Hz		



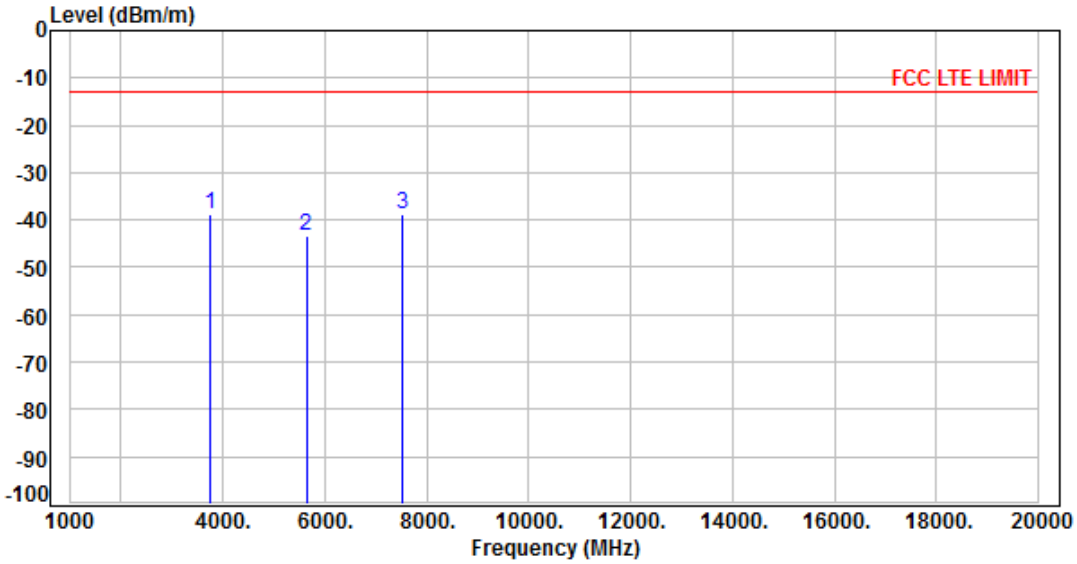
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3701.4	-53.38	V	-40.93	6.75	9.5	-38.18	-13
5552.1	-58.12	V	-41.6	8.43	11.2	-38.83	-13
7402.8	-60.72	V	-40.67	9.63	10.91	-39.39	-13

Test Mode	Cat M1, Band 2 1.4MHz, CH 18607	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



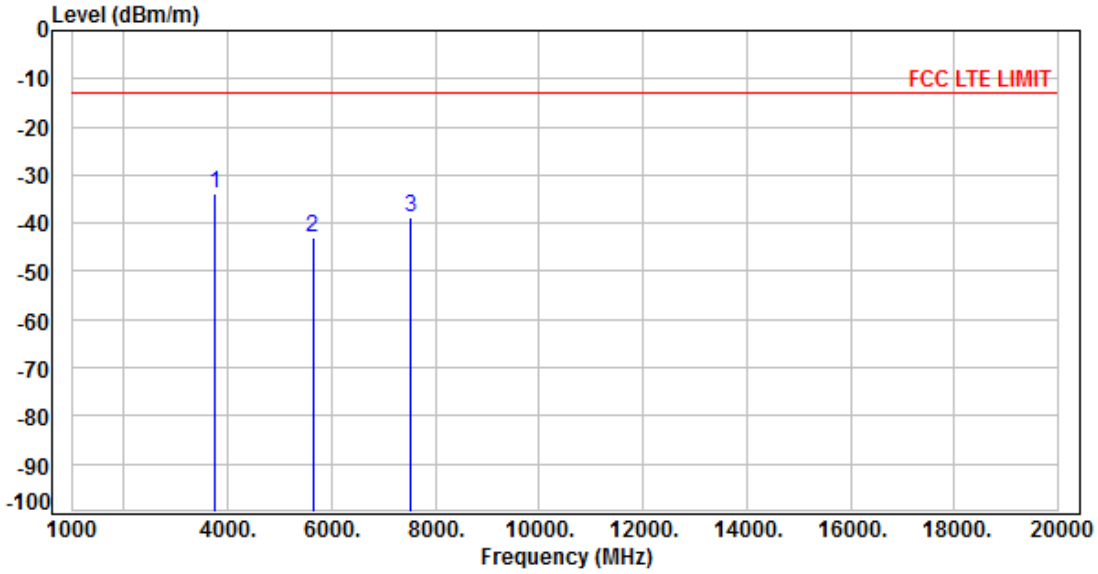
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3701.4	-55.08	H	-42.7	6.75	9.5	-39.95	-13
5552.1	-61.8	H	-45.19	8.43	11.2	-42.42	-13
7402.8	-61	H	-41.09	9.63	10.91	-39.81	-13

Test Mode	Cat M1, Band 2 1.4MHz, CH 18900	Pol/Phase	VERTICAL
Power	AC 120V/60Hz		



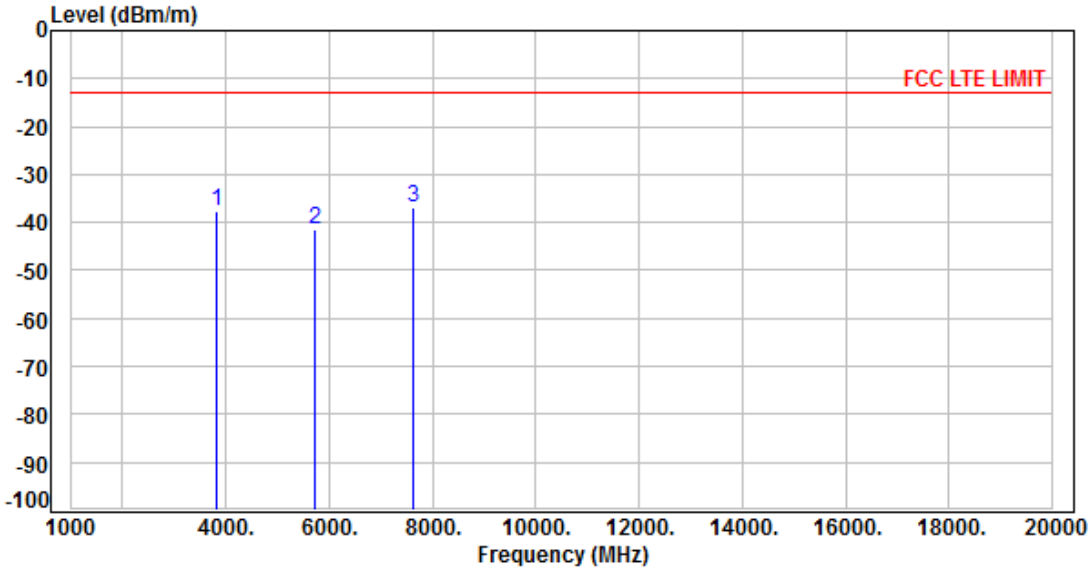
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3760	-54.07	V	-41.18	6.81	9.34	-38.65	-13
5640	-62.86	V	-46.45	8.47	11.54	-43.38	-13
7520	-60.73	V	-40.37	9.71	11.2	-38.88	-13

Test Mode	Cat M1, Band 2 1.4MHz, CH 18900	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



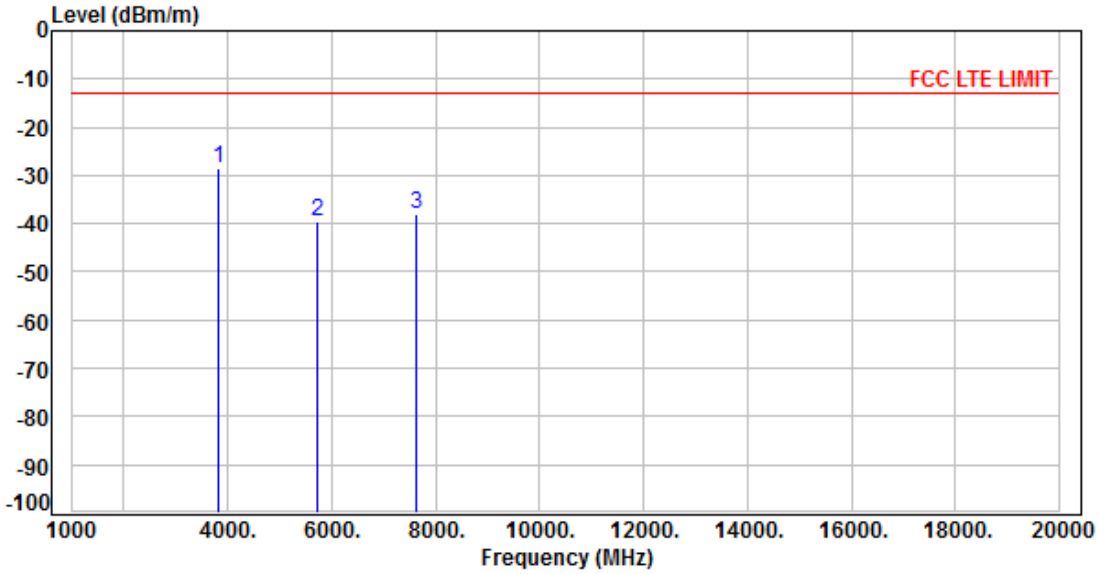
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3760	-49.26	H	-36.38	6.81	9.34	-33.85	-13
5640	-62.58	H	-46.1	8.47	11.54	-43.03	-13
7520	-60.18	H	-40.09	9.71	11.2	-38.6	-13

Test Mode	Cat M1, Band 2 1.4MHz, CH 19193	Pol/Phase	VERTICAL
Power	AC 120V/60Hz		



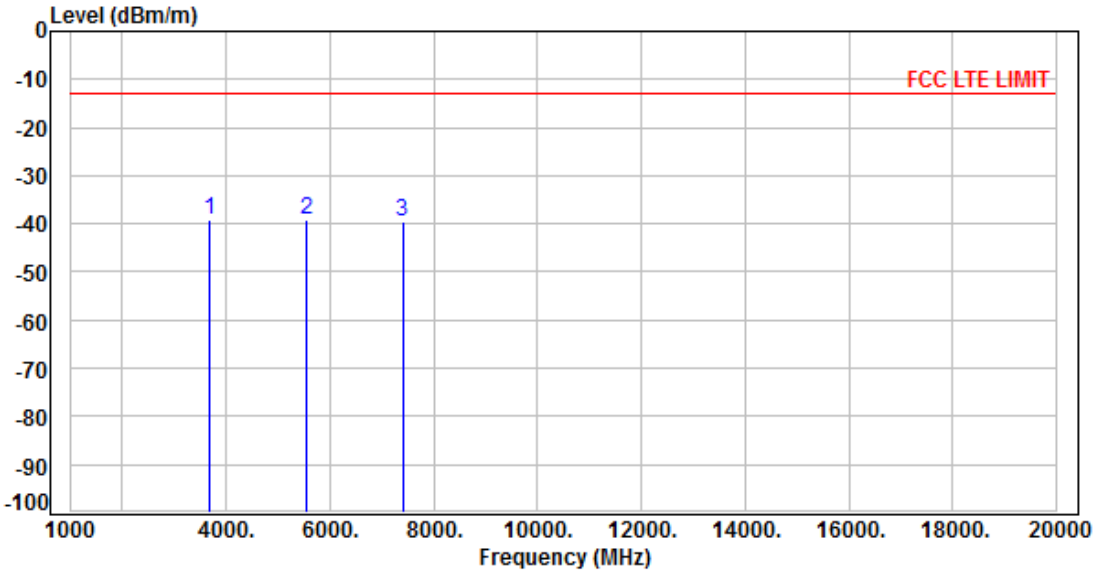
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3818.6	-53.24	V	-40.19	6.86	9.46	-37.59	-13
5727.9	-61.24	V	-44.57	8.51	11.51	-41.57	-13
7637.2	-59.33	V	-38.72	9.8	11.45	-37.07	-13

Test Mode	Cat M1, Band 2 1.4MHz, CH 19193	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



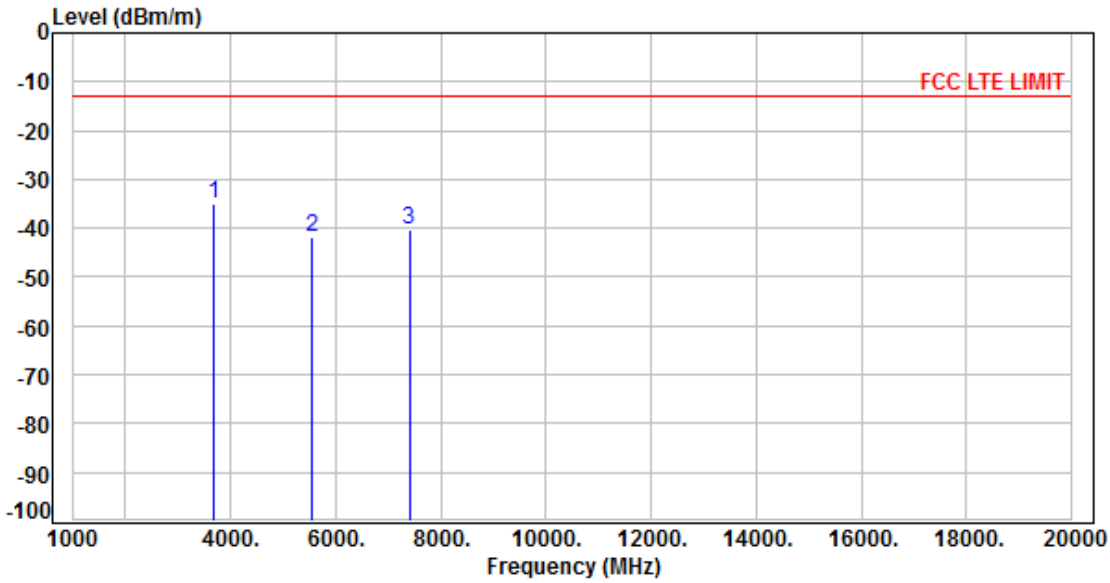
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3818.6	-44.27	H	-31.18	6.86	9.46	-28.58	-13
5727.9	-59.13	H	-42.4	8.51	11.51	-39.4	-13
7637.2	-59.98	H	-39.76	9.8	11.45	-38.11	-13

Test Mode	NB-IoT, Band 2 5MHz, CH 18602	Pol/Phase	VERTICAL
Power	AC 120V/60Hz		



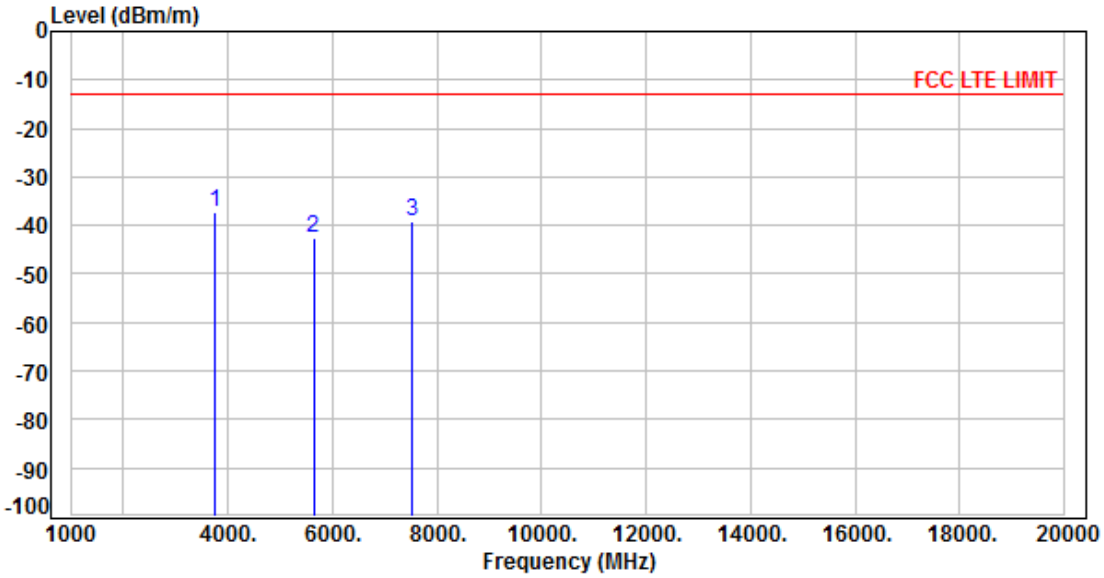
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3700.4	-54.39	V	-41.95	6.74	9.5	-39.19	-13
5550.6	-58.48	V	-41.86	8.43	11.1	-39.19	-13
7400.8	-60.81	V	-40.66	9.63	10.8	-39.49	-13

Test Mode	NB-IoT, Band 2 5MHz, CH 18602	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



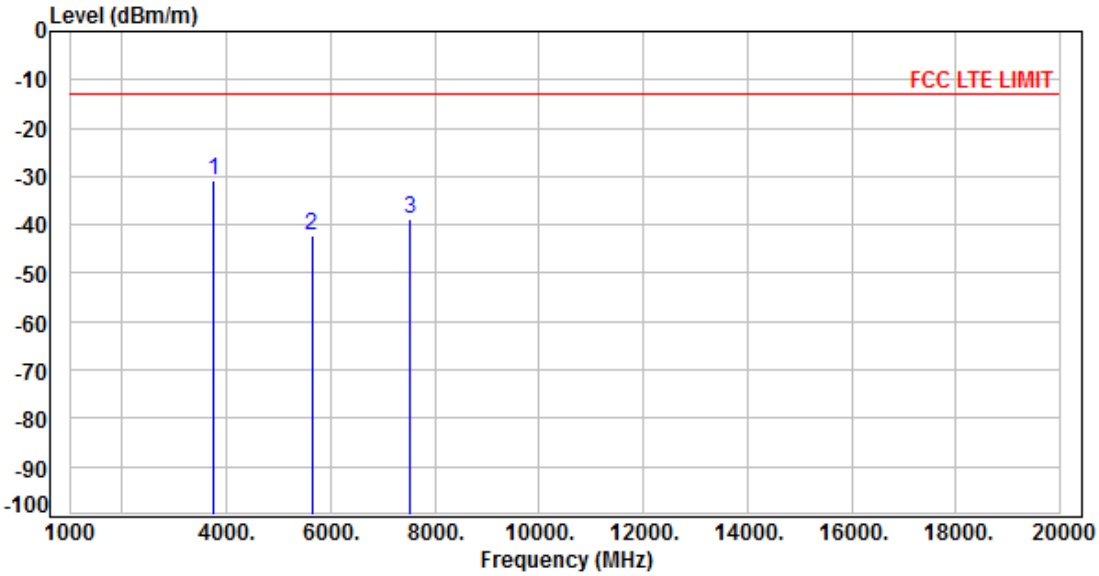
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3700.4	-50.26	H	-37.89	6.74	9.5	-35.13	-13
5550.6	-61.04	H	-44.34	8.43	11.1	-41.67	-13
7400.8	-61.65	H	-41.64	9.63	10.8	-40.47	-13

Test Mode	NB-IoT, Band 2 5MHz, CH 18900	Pol/Phase	VERTICAL
Power	AC 120V/60Hz		



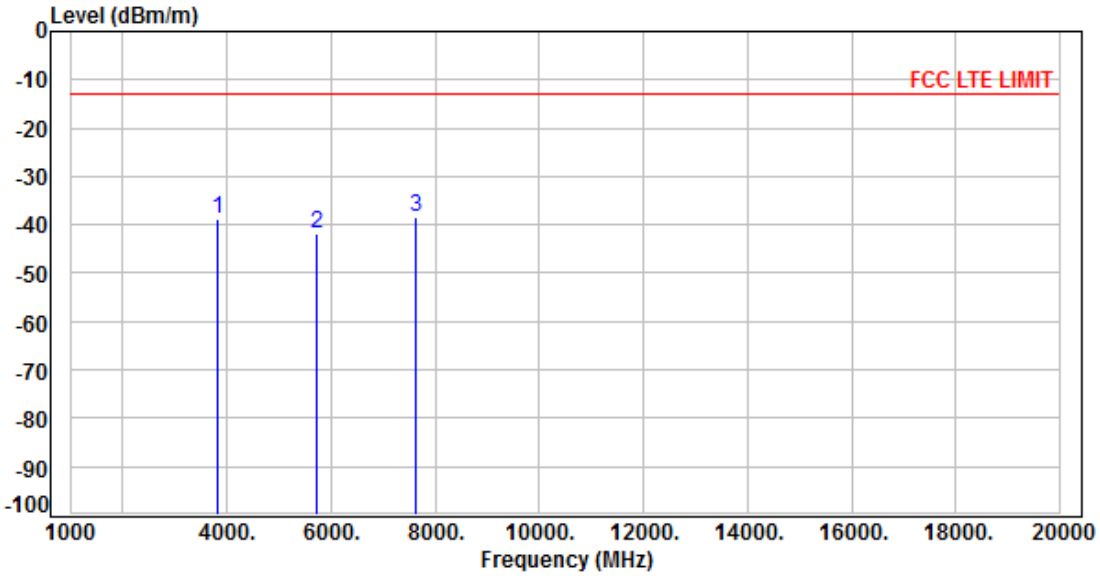
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3760	-52.84	V	-39.99	6.81	9.38	-37.42	-13
5640	-62.05	V	-45.46	8.47	11.36	-42.57	-13
7520	-61.1	V	-40.52	9.71	10.98	-39.25	-13

Test Mode	NB-IoT, Band 2 5MHz, CH 18900	Pol/Phase	HORIZONTAL
Power	AC 120V/60Hz		



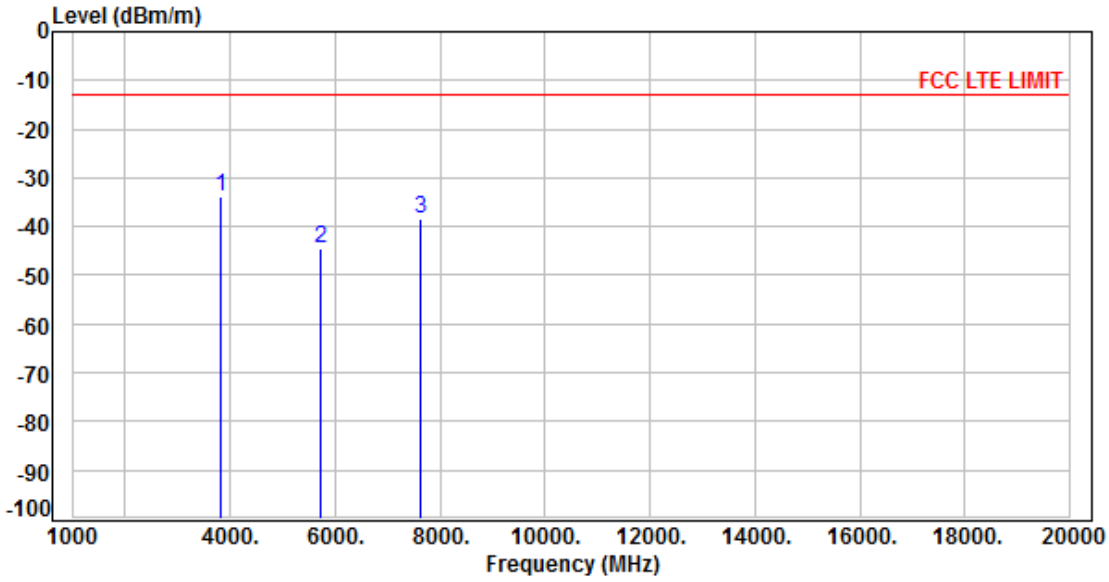
Frequency (MHz)	SA Reading (dBm)	Ant.Pol. (H/V)	SG Reading (dBm)	Cable Loss (dB)	Gain (dBi)	EIRP (dBm)	Limit (dBm)
3760	-46.17	H	-33.33	6.81	9.38	-30.76	-13
5640	-61.82	H	-45.16	8.47	11.36	-42.27	-13
7520	-60.21	H	-39.9	9.71	10.98	-38.63	-13

Test Mode	NB-IoT, Band 2 5MHz, CH 19198	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)
3819.6	-54.43	V	-41.17	6.87	9.26	-38.78	-13
5729.4	-61.59	V	-44.96	8.51	11.56	-41.91	-13
7639.2	-60.72	V	-39.91	9.8	11.26	-38.45	-13

Test Mode	NB-IoT, Band 2 5MHz, CH 19198	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)
3819.6	-49.45	H	-36.13	6.87	9.26	-33.74	-13
5729.4	-64.05	H	-47.37	8.51	11.56	-44.32	-13
7639.2	-60.36	H	-39.94	9.8	11.26	-38.48	-13

11. Frequency Stability (Temperature & Voltage Variation) Test

11.1. Test Limit

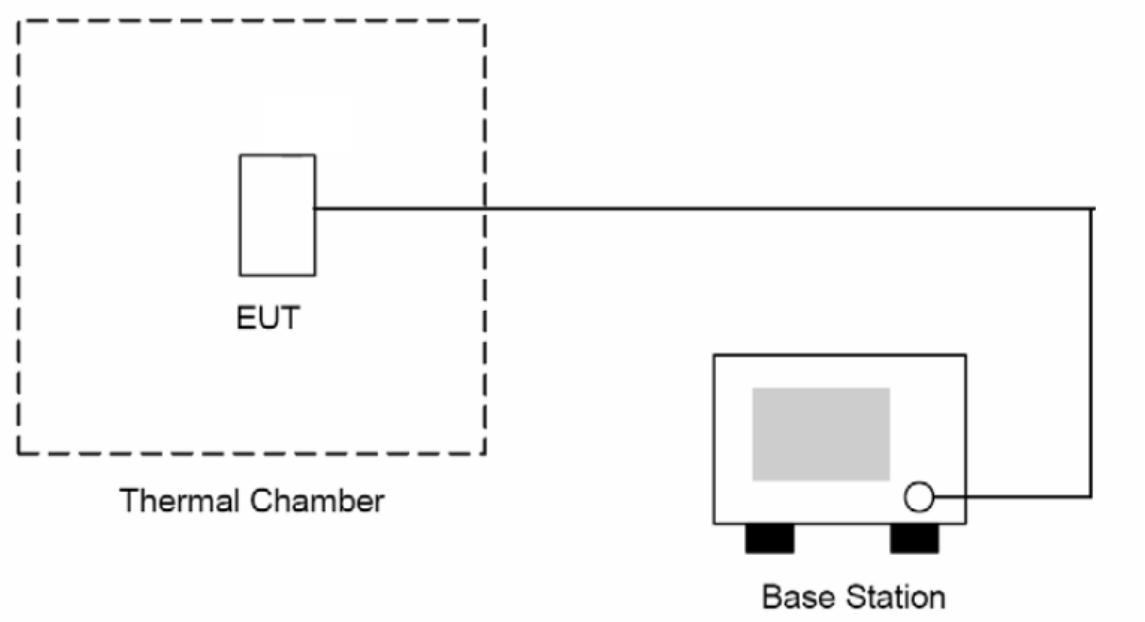
Mobile:
The frequency stability shall be measured by variation of ambient temperature and variation of primary supply voltage to ensure that the fundamental emission stays within the authorized frequency block. The frequency stability of the transmitter shall be maintained within ±0.00025% (±2.5ppm) 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 2 QPSK 20M middle channel

Frequency Stability under Temperature				
Temperature Interval (°C)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
50	1880	1.48	0.001	2.5
40	1880	2.77	0.001	2.5
30	1880	-1.65	-0.001	2.5
20	1880	-0.33	0.000	2.5
10	1880	-0.64	0.000	2.5
0	1880	-2.58	-0.001	2.5
-10	1880	1.26	0.001	2.5
-20	1880	1.99	0.001	2.5
-30	1880	-0.61	0.000	2.5

LTE Band 2 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	1880	2.17	0.001	2.5
120	1880	3.59	0.002	2.5
102	1880	-0.99	-0.001	2.5

NB-IoT

Band 2 QPSK middle channel

Frequency Stability under Temperature				
Temperature Interval (°C)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
50	1880	1.22	0.001	2.5
40	1880	3.48	0.002	2.5
30	1880	3.14	0.002	2.5
20	1880	0.25	0.000	2.5
10	1880	-0.16	0.000	2.5
0	1880	-0.08	0.000	2.5
-10	1880	3.14	0.002	2.5
-20	1880	-0.04	0.000	2.5
-30	1880	-1.29	-0.001	2.5

Band 2 QPSK middle channel

Frequency Stability under Voltage at 20°C				
DC Voltage (V)	Test Frequency (MHz)	Deviation (Hz)	Frequency error (ppm)	Limit (ppm)
138	1880	3.22	0.002	2.5
120	1880	0.19	0.000	2.5
102	1880	-1.58	-0.001	2.5