5.7. RF EXPOSURE REQUIRMENTS [§§ 15.247(i), 1.1310 & 2.1091]

5.7.1. Limits

§ **1.1310:** The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*($900/f^2$)	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*($180/f^2$)	30
30-300	27.5	0.073	0.2	30
300-1500			f/1500	30
1500-100,000			1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

Note 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

Note 2: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

5.7.2. Method of Measurements

Calculation Method of Power Density/RF Safety Distance:

$$S = \frac{PG}{4\pi \cdot r^2} = \frac{EIRP}{4\pi \cdot r^2}$$

Where, P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm^2
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

5.7.3. RF Evaluation

5.7.3.1. Standalone MPE Evaluation

Frequency (MHz)	EIRP (dBm)	EIRP (mW)	Evaluation Distance, r (cm)	Power Density, S (mW/cm^2)	MPE Limit (mW/cm^2)	Margin (mW/cm^2)
2412	36.00	3981.072	25	0.507	1.0	-0.493

5.7.3.2. Co-location MPE Evaluation

Pursuant to KDB 447498 D01 General RF Exposure Guidance v06, Section 7.2:

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0, according to calculated/estimated, numerically modeled, or measured field strengths or power density.

The table below is the possible co-located options of the EUT:

Source / Option	EUT, Microhard Systems Inc. WiFi Module, pX2 Gen2 (FCC ID: NS9A15PX2)	Quectel Wireless Solutions Company Limited, LTE Module, EC25-AF; EC25-AF MINIPCIE (FCC ID: XMR201808EC25AF)	Quectel Wireless Solutions Company Limited, LTE Module, EG25-G, EG25-G MINIPCIE (FCC ID: XMR201903EG25G)	Quectel Wireless Solutions Company Limited, LTE Cat M1 & Cat NB2 & EGPRS Module, BG95-M3, BG95-M3 MINIPCIE (FCC ID: XMR201910BG95M3)	Quectel Wireless Solutions Company Limited, LTE-A Cat 12 M.2 Module, EM12-G (FCC ID: XMR201901EM12G)
1	X	X	--	--	--
2	X	--	X	--	--
3	X	--	--	X	--
4	X	--	--	--	X

Co-location evaluation will only applies to EUT with 2.5 dBi dipole antenna, evaluated at a separation distance of 38 cm. The table below is the calculation for all the possible options and the sum of the MPE ratios from all sources.

	Maximum MPE Ratio					Sum of the MPE ratios from all sources
Source / Option	EUT, Microhard Systems Inc. WiFi Module, pX2 Gen2 (FCC ID: NS9A15PX2)	Quectel Wireless Solutions Company Limited, LTE Module, EC25-AF; EC25-AF MINIPCIE (FCC ID: XMR201808EC25AF)	Quectel Wireless Solutions Company Limited, LTE Module, EG25-G, EG25-G MINIPCIE (FCC ID: XMR201903EG25G)	Quectel Wireless Solutions Company Limited, LTE Cat M1 & Cat NB2 & EGPRS Module, BG95-M3, BG95-M3 MINIPCIE (FCC ID: XMR201910BG95M3)	Quectel Wireless Solutions Company Limited, LTE-A Cat 12 M.2 Module, EM12-G (FCC ID: XMR201901EM12G)	
1	0.120	0.277	--	--	--	0.397
2	0.120	--	0.470	--	--	0.590
3	0.120	--	--	0.277	--	0.397
4	0.120	--	--	--	0.114	0.234

The sum of the MPE ratios from all sources is < 1. Thus, in compliant with the general public (uncontrolled environment) MPE limit.

For detailed MPE ratios calculation, refer to the following tables.

Calculated MPE Ratio for EUT Module					
Frequency (MHz)	[1]Maximum EIRP (dBm)	Maximum EIRP (mW)	Power Density at 38cm (mW/cm^2)	Limit (mW/cm^2)	MPE Ratio
2412	33.38	2177.710	0.1200	1.000	**0.120**
[1] The EUT EIRP is derived from the maximum conducted power of 27.87 dBm + 2.5 dBi antenna gain + array gain of 10*log(2).					

Calculated MPE Ratio for Quectel Wireless Solutions Company Limited, LTE Module, EC25-AF; EC25-AF MINIPCIE								
Operating Mode	[1]Maximum Conducted Power (dBm)	[1]Maximum Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm^2)	Limit (mW/cm^2)	MPE Ratio
WCDMA II	25.00	8.000	33.000	1995.262	38	0.110	1.000	0.110
WCDMA IV	25.00	5.000	30.000	1000.000	38	0.055	1.000	0.055
WCDMA V	25.00	9.416	34.416	2764.394	38	0.152	0.550	**0.277**
LTE Band 2	25.00	8.000	33.000	1995.262	38	0.110	1.000	0.110
LTE Band 4	25.00	5.000	30.000	1000.000	38	0.055	1.000	0.055
LTE Band 5	25.00	9.416	34.416	2764.394	38	0.152	0.550	0.277
LTE Band 12	25.00	8.734	33.734	2362.653	38	0.130	0.470	0.277
LTE Band 13	25.00	9.173	34.173	2613.966	38	0.144	0.520	0.277
LTE Band 14	25.00	9.255	34.255	2663.790	38	0.147	0.530	0.277
LTE Band 66	25.00	5.000	30.000	1000.000	38	0.055	1.000	0.055
LTE Band 71	25.00	8.545	33.545	2262.039	38	0.125	0.450	0.277
[1] Data derived from Quectel LTE Module MPE test report, Test Report No. R1806A0301-M1V3.								

Calculated MPE Ratio for Quectel Wireless Solutions Company Limited, LTE Module, EG25-G, EG25-G MINIPCIE										
Operating Band	**[1]Frequency (MHz)**	**[1]Max Conducted Average Output Power (dBm)**	**[1]Output Power to Antenna (dBm)**	**[1]Max Gain Allowed (dBi)**	**Max. E.I.R.P. (dBm)**	**Max. E.I.R.P. (mW)**	**Evaluation Distance (cm)**	**Power Density (mW/cm^2)**	**FCC Limit (mW/cm^2)**	**MPE Ratio**
GSM850	824.2	25.81	25.95	8.60	34.55	2851.018	38	0.157	0.5495	0.286
GSM1900	1850.2	22.81	24.40	10.19	34.59	2877.398	38	0.159	1.0000	0.159
WCDMA B2	1852.4	25.00	26.59	8.00	34.59	2877.398	38	0.159	1.0000	0.159
WCDMA B4	1712.4	25.00	27.00	5.00	32.00	1584.893	38	0.087	1.0000	0.087
WCDMA B5	826.4	25.00	25.14	9.42	34.56	2857.591	38	0.157	0.5509	0.285
LTE B2	1850.7	25.00	26.59	8.00	34.59	2877.398	38	0.159	1.0000	0.159
LTE B4	1710.7	25.00	27.00	5.00	32.00	1584.893	38	0.087	1.0000	0.087
LTE B5	824.7	25.00	25.14	9.41	34.55	2851.018	38	0.157	0.5498	0.286
LTE B7	2502.5	25.00	28.00	8.00	36.00	3981.072	38	0.219	1.0000	0.219
LTE B12	699.7	25.00	26.11	8.70	34.81	3026.913	38	0.167	0.4665	0.358
LTE B13	779.5	25.00	27.30	9.16	36.46	4425.884	38	0.244	0.5197	**0.470**
LTE B25	1850.7	25.00	26.59	8.00	34.59	2877.398	38	0.159	1.0000	0.159
LTE B26 (814-824)	814.7	25.00	25.38	9.36	34.74	2978.516	38	0.164	0.5431	0.302
LTE B26 (824-849)	824.7	25.00	25.38	9.41	34.79	3013.006	38	0.166	0.5498	0.302
LTE B38	2572.5	25.00	27.06	8.00	35.06	3206.269	38	0.177	1.0000	0.177
LTE B41	2498.5	25.00	28.00	8.00	36.00	3981.072	38	0.219	1.0000	0.219

[1] Data derived from Quectel LTE Module MPE test report, Test Report No. HR/2019/1001602.

Calculated MPE Ratio for Quectel Wireless Solutions Company Limited, LTE Cat M1 & Cat NB2 & EGPRS Module, BG95-M3, BG95-M3 MINIPCIE					
Band	**[1]EIRP (mW)**	**Evaluation Distance (cm)**	**Power Desnity (mW/cm2)**	**Power Density Limit (mW/cm^2)**	**MPE Ratio**
GSM850	2845.116	38	0.157	0.566	**0.277**
GSM1900	1995.262	38	0.110	1.000	0.110
LTE Band 2	1995.262	38	0.110	1.000	0.110
LTE Band 4	1000.000	38	0.055	1.000	0.055
LTE Band 5	2845.116	38	0.157	0.566	0.277
LTE Band 12	2397.728	38	0.132	0.477	0.277
LTE Band 13	2638.761	38	0.145	0.525	0.277
LTE Band 25	1995.262	38	0.110	1.000	0.110
LTE Band 26	2845.116	38	0.157	0.566	0.277
LTE Band 66	1000.000	38	0.055	1.000	0.055
LTE Band 85	2397.728	38	0.132	0.477	0.277
NB-IOT Band 2	1995.262	38	0.110	1.000	0.110
NB-IOT Band 4	1000.000	38	0.055	1.000	0.055
NB-IOT Band 5	2845.116	38	0.157	0.566	0.277
NB-IOT Band 12	2397.728	38	0.132	0.477	0.277
NB-IOT Band 13	2638.761	38	0.145	0.525	0.277
NB-IOT Band 25	1995.262	38	0.110	1.000	0.110
NB-IOT Band 66	1000.000	38	0.055	1.000	0.055
NB-IOT Band 71	2337.222	38	0.129	0.465	0.277
NB-IOT Band 85	2397.728	38	0.132	0.477	0.277

[1] Data derived from Quectel LTE Module MPE test report, Test Report No. R2006A0361-M1V1.

Calculated MPE Ratio for Quectel Wireless Solutions Company Limited, LTE-A Cat 12 M.2 Module, EM12-G									
Band	**[1]Frequency (MHz)**	**[1]Antenna Gain (dBi)**	**[1]Maximum Power (dBm)**	**Maximum EIRP (dBm)**	**Maximum EIRP (mW)**	**Evaluation Distance (cm)**	**Power Density (mW/cm^2)**	**[1]Limit (mW/cm^2)**	**MPE Ratio**
WCDMA Band II	1852.4	7.00	24.00	31.000	1258.925	38	0.069	1.000	0.069
WCDMA Band IV	1712.4	5.00	24.00	29.000	794.328	38	0.044	1.000	0.044
WCDMA Band V	826.4	6.00	24.00	30.000	1000.000	38	0.055	0.551	0.100
LTE Band 2	1850.7	7.00	24.50	31.500	1412.538	38	0.078	1.000	0.078
LTE Band 4	1710.7	5.00	24.50	29.500	891.251	38	0.049	1.000	0.049
LTE Band 5	824.7	6.00	24.50	30.500	1122.018	38	0.062	0.550	0.112
LTE Band 7	2502.5	7.00	24.50	31.500	1412.538	38	0.078	1.000	0.078
LTE Band 12	699.7	5.00	24.50	29.500	891.251	38	0.049	0.466	0.105
LTE Band 13	779.5	5.00	24.50	29.500	891.251	38	0.049	0.520	0.094
LTE Band 14	790.5	5.00	24.50	29.500	891.251	38	0.049	0.527	0.093
LTE Band 17	706.5	5.00	24.50	29.500	891.251	38	0.049	0.471	0.104
LTE Band 25	1850.7	7.00	24.50	31.500	1412.538	38	0.078	1.000	0.078
LTE Band 26	814.7	6.00	24.50	30.500	1122.018	38	0.062	0.543	**0.114**
LTE Band 30	2307.5	4.00	20.50	24.500	281.838	38	0.016	1.000	0.016
LTE Band 38	2572.5	7.00	24.50	31.500	1412.538	38	0.078	1.000	0.078
LTE Band 41	2498.5	7.00	24.50	31.500	1412.538	38	0.078	1.000	0.078
LTE Band 66	1710.7	5.00	24.50	29.500	891.251	38	0.049	1.000	0.049

[1] Data derived from Quectel LTE Module MPE test report, Test Report No. FA8N2911.