

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

§ 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.

5.4.1. 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/cm²
 G: numeric gain of antenna relative to isotropic radiator
 r: distance to centre of radiation in cm

5.4.2. RF 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 EUT is subject to co-location MPE evaluation, below table are the possible options:

Option	Sources
1	- Lyngsoe Systems Ltd. Active RFID Reader (125 kHz TX & 433.92 MHz TX) - Texas Instruments WiFi and Bluetooth Module (FCC ID: Z64-WL18DBMOD) - Impinj, Inc., RFID Reader (FCC ID: TWYIPJREV) - Quectel LTE Module (FCC ID: XMR201906EG21G)
2	- Lyngsoe Systems Ltd. Active RFID Reader (125 kHz TX & 433.92 MHz TX) - Texas Instruments WiFi and Bluetooth Module (FCC ID: Z64-WL18DBMOD) - Impinj, Inc., RFID Reader (FCC ID: TWYIPJREV) - Telit Communications S.p.A. WCDMA and LTE Cellular Wireless Module (FCC ID: RI7LE910CXNF)
3	- Lyngsoe Systems Ltd. Active RFID Reader (125 kHz TX & 433.92 MHz TX) - Texas Instruments WiFi and Bluetooth Module (FCC ID: Z64-WL18DBMOD) - Impinj, Inc., RFID Reader (FCC ID: TWYIPJREV)

Options 1 and 2 will be evaluated as possible worst-case at an evaluation distance of 55 cm.

Sources		Maximum MPE Ratio	
		Option 1	Option 2
Lyngsoe Systems Ltd. Active RFID Reader	125 kHz TX	--	--
	433.92 MHz TX	0.00003	0.00003
Texas Instruments WiFi and Bluetooth Module (FCC ID: Z64-WL18DBMOD)		0.008	0.008
Impinj, Inc., RFID Reader (FCC ID: TWYIPJREV)		0.175	0.175
Quectel LTE Module (FCC ID: XMR201906EG21G)		0.223	--
Telit Communications S.p.A. WCDMA and LTE Cellular Wireless Module (FCC ID: RI7LE910CXNF)		--	0.069
Sum of the MPE ratios for all simultaneously transmitting antennas incorporated within the EUT:		0.406	0.252

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

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

Calculated MPE Ratio for Lyngsoe Systems Ltd. Active RFID Reader						
Frequency (MHz)	EUT EIRP (dBm)	EUT EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)	MPE Ratio
0.125	--	--	55	--	--	--
433.92	-4.63	0.344	55	0.000009	0.2893	0.00003

Calculated MPE Ratio for Texas Instruments WiFi and Bluetooth Module									
Band	Frequency (MHz)	² Antenna Gain (dBi)	¹ Maximum Power (dBm)	¹ Maximum EIRP (dBm)	¹ Maximum EIRP (W)	¹ Average EIRP (mW)	Power Density at 55cm (mW/cm ²)	MPE Limit (mW/cm ²)	MPE Ratio
Bluetooth	2402	3.2	12.5	15.7	0.037	37.154	0.001	1.000	0.001
2.4GHz WLAN	2412	3.2	17.5	20.7	0.117	117.49	0.003	1.000	0.003
5GHz WLAN	5180	4.5	19.5	24	0.251	251.189	0.007	1.000	0.007
Sum of MPE Ratios from Bluetooth and 5GHz WLAN:									0.008
¹ Data derived from Texas Instruments WiFi and Bluetooth Module RF exposure evaluation test report, Test Report No. FA741330.									
² Maximum permitted antenna gain.									

Calculated MPE Ratio for Impinj, Inc., RFID Reader								
Operating Band (MHz)	Frequency (MHz)	¹ Power (dBm)	² Ant Type/ Gain (dBi)	¹ EIRP (dBm)	Distance (cm)	MPE (mW/cm ²)	MPE Limit (mW/cm ²)	MPE Ratio
902-928	902.75	30	6	36	55	0.105	0.601	0.175
¹ Data derived from Impinj, Inc., RFID Reader RF exposure evaluation test report, Test Report No. 101403-9.								
² Maximum permitted antenna gain.								

Calculated MPE Ratio for Quectel LTE Module										
Operating Band	Frequency (MHz)	¹ Max Conducted Average Output Power (dBm)	¹ Output Power to Antenna (dBm)	² Max Gain Allowed (dBi)	Max. E.I.R.P. (dBm)	Max. E.I.R.P. (W)	Evaluation Distance (m)	Power Density (W/m ²)	MPE Limit (W/m ²)	MPE Ratio
GSM850	824.2	25.81	25.95	8.60	34.55	2851.018	55	0.075	0.549	0.137
GSM1900	1850.2	22.81	24.40	10.19	34.59	2877.398	55	0.076	1.000	0.076
WCDMA B2	1852.4	25.00	26.59	8.00	34.59	2877.398	55	0.076	1.000	0.076
WCDMA B4	1712.4	25.00	27.00	5.00	32.00	1584.893	55	0.042	1.000	0.042
WCDMA B5	826.4	25.00	25.14	9.42	34.56	2857.591	55	0.075	0.551	0.136
LTE B2	1850.7	25.00	26.59	8.00	34.59	2877.398	55	0.076	1.000	0.076
LTE B4	1710.7	25.00	27.00	5.00	32.00	1584.893	55	0.042	1.000	0.042
LTE B5	824.7	25.00	25.14	9.41	34.55	2851.018	55	0.075	0.550	0.136
LTE B7	2502.5	25.00	28.00	8.00	36.00	3981.072	55	0.105	1.000	0.105
LTE B12	699.7	25.00	26.11	8.70	34.81	3026.913	55	0.080	0.466	0.172
LTE B13	779.5	25.00	27.30	9.16	36.46	4425.884	55	0.116	0.520	0.223
LTE B25	1850.7	25.00	26.59	8.00	34.59	2877.398	55	0.076	1.000	0.076
LTE B26(814-824)	814.7	25.00	25.38	9.36	34.74	2978.516	55	0.078	0.543	0.144
LTE B26(824-849)	824.7	25.00	25.38	9.41	34.79	3013.006	55	0.079	0.550	0.144
LTE B38	2572.5	25.00	27.06	8.00	35.06	3206.269	55	0.084	1.000	0.084
LTE B41	2498.5	25.00	28.00	8.00	36.00	3981.072	55	0.105	1.000	0.105

¹ Data derived from Quectel LTE Module RF exposure evaluation test report, Test Report No. HR/2019/10016E-0102.
² Maximum permitted antenna gain.

Calculated MPE Ratio for Telit Communications S.p.A. WCDMA and LTE Cellular Wireless Module										
Band	Frequency (MHz)	¹ Maximum conducted output power (per tune-up) (dBm)	Duty Cycle (%)	² Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm ²)	FCC MPE Limit (mW/cm ²)	MPE Ratio
FDD 71	663.0	25.00	100,0%	5.63	30.63	1156.11	55	0.030	0.442	0.069
FDD 12	699.0	25.00	100,0%	5.63	30.63	1156.11	55	0.030	0.466	0.065
FDD 13	777.0	25.00	100,0%	5.94	30.94	1241.65	55	0.033	0.518	0.063
FDD 14	788.0	25.00	100,0%	5.94	30.94	1241.65	55	0.033	0.525	0.062
WCDMA Band V	826.4	25.00	100,0%	6.12	31.12	1294.20	55	0.034	0.551	0.062
FDD 5	824.0	25.00	100,0%	6.12	31.12	1294.20	55	0.034	0.549	0.062
FDD 4	1710.0	25.00	100,0%	5.00	30.00	1000.00	55	0.026	1.0	0.026
FDD 66	1710.0	25.00	100,0%	5.00	30.00	1000.00	55	0.026	1.0	0.026
WCDMA Band IV	1710.0	25.00	100,0%	5.00	30.00	1000.00	55	0.026	1.0	0.026
WCDMA Band II	1850.0	25.00	100,0%	8.01	33.01	1999.86	55	0.053	1.0	0.053
FDD 2	1850.0	25.00	100,0%	8.01	33.01	1999.86	55	0.053	1.0	0.053

¹ Data derived from Telit LTE Module RF exposure evaluation test report, Test Report No. 57536_LE910C4-NF.
² Maximum permitted antenna gain.

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All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)