

FCC RF Exposure Evaluation of Devices

Report Status Sheet

Revision	Report Date	Reason for Revision
∅	June 10, 2021	Initial Issue
1	October 9, 2021	TCB Review Updates

RF Exposure Evaluation of Devices

RF Exposure Requirements: §1.1307(b)(1) and §1.1307(b)(2): Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission’s guidelines.

RF Radiation Exposure Limit: §1.1310: As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(i) Limits for Occupational/Controlled Exposure				
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
300-1,500			f/300	<6
1,500-100,000			5	<6
(ii) 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
300-1,500			f/1500	<30
1,500-100,000			1.0	<30

RF Exposure Limits

$$S = PG / 4\pi R^2 \quad \text{or} \quad R = \sqrt{PG / 4\pi S}$$

where, S = Power Density (mW/cm²)
P = Power Input to antenna (mW)
G = Antenna Gain (numeric value)
R = Distance (cm)

For Antenna Gain → **dBi = 10log(Numeric)**

Technology	TX Frequency Range	Peak Gain	Type
GSM 850	824 – 849 MHz	3.5 dBi	Ceramic Chip
GSM 1900	1850 – 1910 MHz	4.0 dBi	Ceramic Chip
LTE CAT-M1 Band 2	1850 – 1910 MHz	4.0 dBi	Ceramic Chip
LTE CAT-M1 Band 4	1710 – 1755 MHz	4.0 dBi	Ceramic Chip
LTE CAT-M1 Band 5	814 – 849 MHz	3.5 dBi	Ceramic Chip
LTE CAT-M1 Band 12	699 – 716 MHz	3.5 dBi	Ceramic Chip
LTE CAT-M1 Band 13	777 – 787 MHz	3.5 dBi	Ceramic Chip
LTE CAT-M1 Band 25	1850 – 1915 MHz	4.0 dBi	Ceramic Chip
LTE CAT-M1 Band 26	824 – 849 MHz	3.5 dBi	Ceramic Chip
LTE CAT-M1 Band 66	1710 – 1755 MHz	4.0 dBi	Ceramic Chip
LTE CAT-M1 Band 85	698 – 716 MHz	3.5 dBi	Ceramic Chip
NB-IoT Band 2	1850 – 1910 MHz	4.0 dBi	Ceramic Chip
NB-IoT Band 4	1710 – 1755 MHz	4.0 dBi	Ceramic Chip
NB-IoT Band 5	814 – 849 MHz	3.5 dBi	Ceramic Chip
NB-IoT Band 12	699 – 716 MHz	3.5 dBi	Ceramic Chip
NB-IoT Band 13	777 – 787 MHz	3.5 dBi	Ceramic Chip
NB-IoT Band 25	1850 – 1915 MHz	4.0 dBi	Ceramic Chip
NB-IoT Band 26	824 – 849 MHz	3.5 dBi	Ceramic Chip
NB-IoT Band 66	1850 – 1910 MHz	4.0 dBi	Ceramic Chip
NB-IoT Band 71	663 – 698 MHz	3.5 dBi	Ceramic Chip
NB-IoT Band 85	698 – 716 MHz	3.5 dBi	Ceramic Chip
BLE	2402 – 2480 MHz	-3.0 dBi	PCB Trace
LoRa	902 – 928 MHz	-2.5 dBi	SMD Helical
WiFi 2.4 GHz	2412 – 2462 MHz	3.5 dBi	PCB Trace
WiFi 5.0 GHz	5180 – 5825 MHz	4.5 dBi	PCB Trace

EUT Antenna Gain Specifications

Test Results:

Band	Frequency (MHz)	Maximum Conducted Power (dBm)	Conducted Power (mW)	Antenna Gain (dBi)	Antenna Gain (Numeric)	Power Density (mW/cm ²)	Limit (mW/cm ²)	Margin	Distance (cm)	Result
GSM 850	831.5	26	398.11	3.5	2.239	0.177	0.554	0.377	20	Pass
GSM 1900	1880.0	23	199.53	4	2.512	0.100	1	0.900	20	Pass
LTE B2	1880.00	25	316.23	4	2.512	0.158	1	0.842	20	Pass
LTE B4	1732.5	25	316.23	4	2.512	0.158	1	0.842	20	Pass
LTE B5	836.5	25	316.23	3.5	2.239	0.141	0.558	0.417	20	Pass
LTE B12	707.5	25	316.23	3.5	2.239	0.141	0.472	0.331	20	Pass
LTE B13	782.0	25	316.23	3.5	2.239	0.141	0.521	0.380	20	Pass
LTE B25	1882.5	25	316.23	4	2.512	0.158	1	0.842	20	Pass
LTE B26	831.5	25	316.23	3.5	2.239	0.141	0.554	0.413	20	Pass
LTE B66	1710.0	25	316.23	4	2.512	0.158	1	0.842	20	Pass
LTE B85	689.0	25	316.23	3.5	2.239	0.141	0.459	0.318	20	Pass
NB-IoT Band 2	1880.00	25	316.23	4	2.512	0.158	1	0.842	20	Pass
NB-IoT Band 4	1732.5	25	316.23	4	2.512	0.158	1	0.842	20	Pass
NB-IoT Band 5	836.5	25	316.23	3.5	2.239	0.141	0.558	0.417	20	Pass
NB-IoT Band 12	707.5	25	316.23	3.5	2.239	0.141	0.472	0.331	20	Pass
NB-IoT Band 13	782.0	25	316.23	3.5	2.239	0.141	0.521	0.380	20	Pass
NB-IoT Band 25	1882.5	25	316.23	4	2.512	0.158	1	0.842	20	Pass
NB-IoT Band 26	831.5	25	316.23	3.5	2.239	0.141	0.554	0.413	20	Pass
NB-IoT Band 66	1745.0	25	316.23	4	2.512	0.158	1	0.842	20	Pass
NB-IoT Band 71	680.5	25	316.23	3.5	2.239	0.141	0.454	0.313	20	Pass
NB-IoT Band 85	707.0	25	316.23	3.5	2.239	0.141	0.471	0.330	20	Pass
BLE	2402.0	3	2.00	-3	0.501	0.0002	1	1.000	20	Pass
LoRa	902.0	19	79.43	-2.5	0.562	0.0089	0.601	0.592	20	Pass
WiFi 2.4 GHz	2412.0	16	39.81	3.5	2.239	0.018	1	0.982	20	Pass
WiFi 5.0 GHz	5180.0	15	31.62	4.5	2.818	0.018	1	0.982	20	Pass

MPE Calculation for Bands

The safe distance where Power Density is less than the MPE limit listed above was found to be 20 cm.

Note: Results are based on KDB 447498 D01 (Section 7.2) Transmitters used in mobile devices exposure conditions for simultaneous transmission operations.

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 MPE ratio of each antenna is determined at the minimum test separation distance required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to the MPE limit at the test frequency.

There are two(2) BLE radios and two(2) LoRa radios in the EUT in addition to a cellular module. A pre-certified WiFi module is also present in the EUT.

The two(2) BLE radios are identical with same radio chip and RF path components.

The two(2) LoRa radios are identical with same radio chip and RF path components.

Cellular, BLE, LoRa and WiFi radios can transmit simultaneously.

The formula for calculating the simultaneous MPE is

$$\text{CPD1/LPD1} + \text{CPD2/LPD2} + \dots + \text{CPDn/LPDn} < 1$$

CPD: Calculated Power Density

LPD: Limit of Power Density

$$\begin{aligned} \text{Simultaneous MPE} &= \text{Cellular} + \text{BLE1} + \text{BLE2} + \text{LoRa1} + \text{LoRa2} + \text{WiFi} \\ &= 0.141/0.454 + 0.0002/1 + 0.0002/1 + 0.0089/0.601 + 0.0089/0.601 + 0.018/1 \\ &= 0.310 + 0.0002 + 0.0002 + 0.0148 + 0.0148 + 0.018 \\ &= 0.358 \end{aligned}$$

Result: $0.358 < 1$ (Pass)