



## MPE Report

Exposure category: General population/uncontrolled environment

EUT Type: Production Unit

Device Type: Mobile Device

Refer Standard: KDB 447498 D01 General RF Exposure Guidance v06

FCC Part 2 §2.1091

### 1. Evaluation method

Systems operating under the provisions of FCC 47 CFR section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

In accordance with 47 CFR FCC Part 2 Subpart J, section 2.1091 this device has been defined as mobile device whereby a distance of 0.2m normally can be maintained between the user and the device, and below RF Permissible Exposure limit shall comply with.

In accordance with KDB447498D01 for Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneous transmitting antennas incorporated in a host device, based on the calculated/estimated, numerically modeled or measured field strengths or power density, is  $\leq 1.0$ . 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 MPE limit, at the test frequency. Either the maximum peak or spatially averaged results from measurements or numerical simulations may be used to determine the MPE ratios. Spatial averaging does not apply when MPE is estimated using simple calculations based on far-field plane-wave equivalent conditions. The antenna installation and operating requirements for the host device must meet the minimum test separation distances required by all antennas, in both standalone and simultaneous transmission operations, to satisfy compliance.

### 2. Limits for General Population/Uncontrolled Exposure

(B) Limits for General Population / Uncontrolled Exposure

| Frequency Range (MHz) | Electric Field Strength (E) (V/m) | Magnetic Field Strength (H) (A/m) | Power Density (S) (mW/cm <sup>2</sup> ) | Averaging Time  E  <sup>2</sup> ,  H  <sup>2</sup> or S (minutes) |
|-----------------------|-----------------------------------|-----------------------------------|-----------------------------------------|-------------------------------------------------------------------|
| 0.3-1.34              | 614                               | 1.63                              | (100)*                                  | 30                                                                |
| 1.34-30               | 824/f                             | 2.19/f                            | (180/f)*                                | 30                                                                |
| 30-300                | 27.5                              | 0.073                             | 0.2                                     | 30                                                                |
| 300-1500              |                                   |                                   | F/1500                                  | 30                                                                |
| 1500-100,000          |                                   |                                   | 1.0                                     | 30                                                                |

Note: f = frequency in MHz ; \*Plane-wave equivalent power density

### 3. Calculation Method

Predication of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2$$

Where: S=power density



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P=power input to antenna

G=power gain of the antenna in the direction of interest relative to anisotropic radiator

R=distance to the center of radiation of the antenna

From the EUT RF output power, the minimum mobile separation distance,  $d=0.2\text{m}$ , as well as the maximum gain of the used as following information, the RF power density can be obtained.

| Frequency Band | Antenna type and antenna number | Internal Identification | Maximum antenna gain |
|----------------|---------------------------------|-------------------------|----------------------|
| 2.4GHz         | Internal antenna                | Antenna 0               | 4dBi                 |
| 2.4GHz         |                                 | Antenna 1               | 4dBi                 |
| 5GHz           |                                 | Antenna 2               | 4dBi                 |
| 5GHz           |                                 | Antenna 3               | 4dBi                 |



#### 4. Estimation Result

##### 4.1 Conducted Power Results

###### 2.4GHz WIFI

| Antenna   | Mode              | Frequency(MHz) | Peak Conducted Output Power (dBm) |
|-----------|-------------------|----------------|-----------------------------------|
| Antenna 0 | IEEE 802.11b      | 2412           | 20.95                             |
|           |                   | 2437           | 19.62                             |
|           |                   | 2462           | 20.75                             |
|           | IEEE 802.11g      | 2412           | 22.92                             |
|           |                   | 2437           | 22.27                             |
|           |                   | 2462           | 20.75                             |
|           | IEEE 802.11n HT20 | 2412           | 22.98                             |
|           |                   | 2437           | 22.28                             |
|           |                   | 2462           | 17.68                             |
|           | IEEE 802.11n HT40 | 2422           | 22.77                             |
|           |                   | 2437           | 22.13                             |
|           |                   | 2452           | 17.27                             |

| Antenna   | Mode              | Frequency(MHz) | Peak Conducted Output Power (dBm) |
|-----------|-------------------|----------------|-----------------------------------|
| Antenna 1 | IEEE 802.11b      | 2412           | 20.02                             |
|           |                   | 2437           | 20.27                             |
|           |                   | 2462           | 19.72                             |
|           | IEEE 802.11g      | 2412           | 22.37                             |
|           |                   | 2437           | 22.78                             |
|           |                   | 2462           | 20.88                             |
|           | IEEE 802.11n HT20 | 2412           | 21.93                             |
|           |                   | 2437           | 22.87                             |
|           |                   | 2462           | 18.02                             |
|           | IEEE 802.11n HT40 | 2422           | 21.09                             |
|           |                   | 2437           | 21.88                             |
|           |                   | 2452           | 17.32                             |

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**5GHz WIFI**

| Antenna   | Mode              | Frequency(MHz) | Average Conducted Output Power (dBm) |
|-----------|-------------------|----------------|--------------------------------------|
| Antenna 2 | IEEE 802.11a      | 5180           | 16.55                                |
|           |                   | 5200           | 16.91                                |
|           |                   | 5240           | 16.92                                |
|           |                   | 5745           | 15.77                                |
|           |                   | 5785           | 15.13                                |
|           |                   | 5825           | 14.89                                |
|           | IEEE 802.11n HT20 | 5180           | 16.25                                |
|           |                   | 5200           | 16.51                                |
|           |                   | 5240           | 16.81                                |
|           |                   | 5745           | 12.67                                |
|           |                   | 5785           | 11.84                                |
|           |                   | 5825           | 11.83                                |
|           | IEEE 802.11n HT40 | 5190           | 17.28                                |
|           |                   | 5230           | 14.43                                |
|           |                   | 5755           | 13.25                                |
|           |                   | 5795           | 12.71                                |
|           | IEEE 802.11ac 80  | 5210           | 16.47                                |
|           |                   | 5775           | 15.09                                |

| Antenna   | Mode              | Frequency(MHz) | Average Conducted Output Power (dBm) |
|-----------|-------------------|----------------|--------------------------------------|
| Antenna 3 | IEEE 802.11a      | 5180           | 15.18                                |
|           |                   | 5200           | 15.14                                |
|           |                   | 5240           | 14.89                                |
|           |                   | 5745           | 13.70                                |
|           |                   | 5785           | 14.14                                |
|           |                   | 5825           | 14.23                                |
|           | IEEE 802.11n HT20 | 5180           | 15.01                                |
|           |                   | 5200           | 15.04                                |
|           |                   | 5240           | 14.89                                |
|           |                   | 5745           | 12.26                                |
|           |                   | 5785           | 12.99                                |
|           |                   | 5825           | 12.86                                |
|           | IEEE 802.11n HT40 | 5190           | 15.89                                |
|           |                   | 5230           | 12.56                                |
|           |                   | 5755           | 13.36                                |
|           |                   | 5795           | 13.57                                |
|           | IEEE 802.11ac 80  | 5210           | 15.83                                |
|           |                   | 5775           | 15.73                                |



## 4.2 Manufacturing tolerance

**2.4GHz WIFI**

| <b>IEEE 802.11b</b>       |           |      |      |           |      |      |
|---------------------------|-----------|------|------|-----------|------|------|
| Frequency (MHz)           | Antenna 0 |      |      | Antenna 1 |      |      |
|                           | 2412      | 2437 | 2462 | 2412      | 2437 | 2462 |
| Target (dBm)              | 20.0      | 19.0 | 20.0 | 20.0      | 20.0 | 19.0 |
| Tolerance $\pm$ (dB)      | 1.0       | 1.0  | 1.0  | 1.0       | 1.0  | 1.0  |
| <b>IEEE 802.11 g</b>      |           |      |      |           |      |      |
| Frequency (MHz)           | Antenna 0 |      |      | Antenna 1 |      |      |
|                           | 2412      | 2437 | 2462 | 2412      | 2437 | 2462 |
| Target (dBm)              | 22.0      | 22.0 | 20.0 | 22.0      | 22.0 | 20.0 |
| Tolerance $\pm$ (dB)      | 1.0       | 1.0  | 1.0  | 1.0       | 1.0  | 1.0  |
| <b>IEEE 802.11 n HT20</b> |           |      |      |           |      |      |
| Frequency (MHz)           | Antenna 0 |      |      | Antenna 1 |      |      |
|                           | 2412      | 2437 | 2462 | 2412      | 2437 | 2462 |
| Target (dBm)              | 22.0      | 22.0 | 17.0 | 21.0      | 22.0 | 18.0 |
| Tolerance $\pm$ (dB)      | 1.0       | 1.0  | 1.0  | 1.0       | 1.0  | 1.0  |
| <b>IEEE 802.11 n HT40</b> |           |      |      |           |      |      |
| Frequency (MHz)           | Antenna 0 |      |      | Antenna 1 |      |      |
|                           | 2412      | 2437 | 2462 | 2412      | 2437 | 2462 |
| Target (dBm)              | 22.0      | 22.0 | 17.0 | 21.0      | 21.0 | 17.0 |
| Tolerance $\pm$ (dB)      | 1.0       | 1.0  | 1.0  | 1.0       | 1.0  | 1.0  |

**5GHz WIFI**

| <b>IEEE 802.11 a (Average)</b>     |           |      |      |           |      |      |
|------------------------------------|-----------|------|------|-----------|------|------|
| Frequency (MHz)                    | Antenna 2 |      |      | Antenna 3 |      |      |
|                                    | 5180      | 5200 | 5240 | 5180      | 5200 | 5240 |
| Target (dBm)                       | 16.0      | 16.0 | 16.0 | 15.0      | 15.0 | 14.0 |
| Tolerance $\pm$ (dB)               | 1.0       | 1.0  | 1.0  | 1.0       | 1.0  | 1.0  |
| <b>IEEE 802.11 a (Average)</b>     |           |      |      |           |      |      |
| Frequency (MHz)                    | Antenna 2 |      |      | Antenna 3 |      |      |
|                                    | 5745      | 5785 | 5825 | 5745      | 5785 | 5825 |
| Target (dBm)                       | 15.0      | 15.0 | 14.0 | 13.0      | 14.0 | 14.0 |
| Tolerance $\pm$ (dB)               | 1.0       | 1.0  | 1.0  | 1.0       | 1.0  | 1.0  |
| <b>IEEE 802.11n HT20 (Average)</b> |           |      |      |           |      |      |
| Frequency (MHz)                    | Antenna 2 |      |      | Antenna 3 |      |      |
|                                    | 5180      | 5200 | 5240 | 5180      | 5200 | 5240 |
| Target (dBm)                       | 16.0      | 16.0 | 16.0 | 15.0      | 15.0 | 14.0 |
| Tolerance $\pm$ (dB)               | 1.0       | 1.0  | 1.0  | 1.0       | 1.0  | 1.0  |
| <b>IEEE 802.11n HT20 (Average)</b> |           |      |      |           |      |      |
| Frequency (MHz)                    | Antenna 2 |      |      | Antenna 3 |      |      |
|                                    | 5745      | 5785 | 5825 | 5745      | 5785 | 5825 |
| Target (dBm)                       | 12.0      | 12.0 | 11.0 | 12.0      | 12.0 | 12.0 |
| Tolerance $\pm$ (dB)               | 1.0       | 1.0  | 1.0  | 1.0       | 1.0  | 1.0  |



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| IEEE 802.11n HT40 (Average) |           |     |      |           |     |      |
|-----------------------------|-----------|-----|------|-----------|-----|------|
| Frequency (MHz)             | Antenna 2 |     |      | Antenna 3 |     |      |
|                             | 5190      | --- | 5230 | 5190      | --- | 5230 |
| Target (dBm)                | 17.0      | --- | 14.0 | 15.0      | --- | 12.0 |
| Tolerance $\pm$ (dB)        | 1.0       | --- | 1.0  | 1.0       | --- | 1.0  |
| IEEE 802.11n HT40 (Average) |           |     |      |           |     |      |
| Frequency (MHz)             | Antenna 2 |     |      | Antenna 3 |     |      |
|                             | 5755      | --- | 5795 | 5755      | --- | 5795 |
| Target (dBm)                | 13.0      | --- | 12.0 | 13.0      | --- | 13.0 |
| Tolerance $\pm$ (dB)        | 1.0       | --- | 1.0  | 1.0       | --- | 1.0  |
| IEEE 802.11ac 80 (Average)  |           |     |      |           |     |      |
| Frequency (MHz)             | Antenna 2 |     |      | Antenna 3 |     |      |
|                             | 5210      | --- | 5775 | 5210      | --- | 5775 |
| Target (dBm)                | 16.0      | --- | 15.0 | 15.0      | --- | 15.0 |
| Tolerance $\pm$ (dB)        | 1.0       | --- | 1.0  | 1.0       | --- | 1.0  |



### 4.3 Measurement Results

#### 4.3.1 Standalone MPE

##### 2.4GWLAN

###### Antenna 0

| Mode               | Output power |          | Antenna Gain (dBi) | Antenna Gain (linear) | Duty Cycle | MPE (mW/cm <sup>2</sup> ) | MPE Limits (mW/cm <sup>2</sup> ) |
|--------------------|--------------|----------|--------------------|-----------------------|------------|---------------------------|----------------------------------|
|                    | (dBm)        | (mW)     |                    |                       |            |                           |                                  |
| IEEE 802.11 b      | 21.00        | 125.8925 | 4                  | 2.5119                | 100%       | 0.0629                    | 1.0000                           |
| IEEE 802.11 g      | 23.00        | 199.5262 | 4                  | 2.5119                | 100%       | 0.0998                    | 1.0000                           |
| IEEE 802.11 n HT20 | 23.00        | 199.5262 | 4                  | 2.5119                | 100%       | 0.0998                    | 1.0000                           |
| IEEE 802.11 n HT40 | 23.00        | 199.5262 | 4                  | 2.5119                | 100%       | 0.0998                    | 1.0000                           |

###### Antenna 1

| Mode               | Output power |          | Antenna Gain (dBi) | Antenna Gain (linear) | Duty Cycle | MPE (mW/cm <sup>2</sup> ) | MPE Limits (mW/cm <sup>2</sup> ) |
|--------------------|--------------|----------|--------------------|-----------------------|------------|---------------------------|----------------------------------|
|                    | (dBm)        | (mW)     |                    |                       |            |                           |                                  |
| IEEE 802.11 b      | 21.00        | 125.8925 | 4                  | 2.5119                | 100%       | 0.0629                    | 1.0000                           |
| IEEE 802.11 g      | 23.00        | 199.5262 | 4                  | 2.5119                | 100%       | 0.0998                    | 1.0000                           |
| IEEE 802.11 n HT20 | 23.00        | 199.5262 | 4                  | 2.5119                | 100%       | 0.0998                    | 1.0000                           |
| IEEE 802.11 n HT40 | 22.00        | 158.4893 | 4                  | 2.5119                | 100%       | 0.0792                    | 1.0000                           |

##### 5GWLAN

###### Antenna 2

| Mode               | Output power |         | Antenna Gain (dBi) | Antenna Gain (linear) | Duty Cycle | MPE (mW/cm <sup>2</sup> ) | MPE Limits (mW/cm <sup>2</sup> ) |
|--------------------|--------------|---------|--------------------|-----------------------|------------|---------------------------|----------------------------------|
|                    | (dBm)        | (mW)    |                    |                       |            |                           |                                  |
| IEEE 802.11 a      | 17.0         | 50.1187 | 4                  | 2.5119                | 100%       | 0.0251                    | 1.0000                           |
| IEEE 802.11 n HT20 | 17.0         | 50.1187 | 4                  | 2.5119                | 100%       | 0.0251                    | 1.0000                           |
| IEEE 802.11 n HT40 | 18.0         | 63.0957 | 4                  | 2.5119                | 100%       | 0.0315                    | 1.0000                           |
| IEEE 802.11 ac 80  | 17.0         | 50.1187 | 4                  | 2.5119                | 100%       | 0.0251                    | 1.0000                           |

###### Antenna 3

| Mode               | Output power |         | Antenna Gain (dBi) | Antenna Gain (linear) | Duty Cycle | MPE (mW/cm <sup>2</sup> ) | MPE Limits (mW/cm <sup>2</sup> ) |
|--------------------|--------------|---------|--------------------|-----------------------|------------|---------------------------|----------------------------------|
|                    | (dBm)        | (mW)    |                    |                       |            |                           |                                  |
| IEEE 802.11 a      | 16.0         | 39.8107 | 4                  | 2.5119                | 100%       | 0.0199                    | 1.0000                           |
| IEEE 802.11 n HT20 | 16.0         | 39.8107 | 4                  | 2.5119                | 100%       | 0.0199                    | 1.0000                           |
| IEEE 802.11 n HT40 | 16.0         | 39.8107 | 4                  | 2.5119                | 100%       | 0.0199                    | 1.0000                           |
| IEEE 802.11 ac 80  | 16.0         | 39.8107 | 4                  | 2.5119                | 100%       | 0.0199                    | 1.0000                           |

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**Remark:**

1. Maximum average power including tune-up tolerance;
2. MPE use distance is 20cm from manufacturer declaration of user manual.

According to KDB447498 for Transmitters used in mobile exposure conditions for simultaneous transmission operations;

$\Sigma$  of MPE ratios  $\leq$  1.0

We first evaluate WLAN simultaneous transmission and later evaluate WLAN simultaneous transmission;

**Antenna 0 and Antenna 1 for 2.4GWLAN**

| Band | Mode              | MPE Ratio<br>Antenna 0 | MPE Ratio<br>Antenna 1 | $\Sigma$ MPE ratios | Limit | Results |
|------|-------------------|------------------------|------------------------|---------------------|-------|---------|
| 2.4G | IEEE 802.11b      | 0.0629                 | 0.0629                 | N/A                 | 1.000 | Pass    |
|      | IEEE 802.11g      | 0.0998                 | 0.0998                 | N/A                 | 1.000 | Pass    |
|      | IEEE 802.11n HT20 | 0.0998                 | 0.0998                 | 0.1996              | 1.000 | Pass    |
|      | IEEE 802.11n HT40 | 0.0998                 | 0.0792                 | 0.1790              | 1.000 | Pass    |

**Antenna 2 and Antenna 3 for 5GWLAN**

| Band | Mode              | MPE Ratio<br>Antenna 2 | MPE Ratio<br>Antenna 3 | $\Sigma$ MPE ratios | Limit | Results |
|------|-------------------|------------------------|------------------------|---------------------|-------|---------|
| 5G   | IEEE 802.11a      | 0.0251                 | 0.0199                 | N/A                 | 1.000 | Pass    |
|      | IEEE 802.11n HT20 | 0.0251                 | 0.0199                 | 0.0450              | 1.000 | Pass    |
|      | IEEE 802.11n HT40 | 0.0315                 | 0.0199                 | 0.0514              | 1.000 | Pass    |
|      | IEEE 802.11ac 80  | 0.0251                 | 0.0199                 | 0.0450              | 1.000 | Pass    |

**Remark:**

1. Maximum average power including tune-up tolerance;
2. MPE use distance is 20cm from manufacturer declaration of user manual.

**Maximum MPE Ratios for 2.4GHz and 5GHz WLAN simultaneous transmission**

| Maximum MPE Ratio <sub>2.4GHzWLAN</sub> | Maximum MPE Ratio <sub>5GHzWLAN</sub> | $\Sigma$ MPE ratios | Limit | Results |
|-----------------------------------------|---------------------------------------|---------------------|-------|---------|
| 0.1996                                  | 0.0514                                | 0.251               | 1.000 | Pass    |

**Conclusion**

The measurement results comply with the FCC Limit per 47 CFR 2.1091 for the uncontrolled RF Exposure of mobile device.

----- END OF REPORT -----