

## **1. RF EXPOSURE**

### **1.1.The Requirement**

System 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. See Section 15.247 and Section 15.407

### **1.2.Limit For Maximum Permissible Exposure (MPE)**

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 ^2,  H ^2$ 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                                           |

F = frequency in MHz,      \* Plane-wave equivalent power density

### **1.3.MPE 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

P=power input to antenna

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

R=distance to the center of radiation of the antenna

From the peak EUT RF output power, the minimum mobile separation distance,  $d=0.2\text{m}$ , as well as the gain of the antenna is 2 dBi, the RF power density can be obtained.

## 1.4.TEST RESULTS

Maximum measured transmitter power

Directional gain=  $2+10\log 2=5.01$

For 2.4G WIFI

| The test was performed with 802.11b |                             |                              |                           |                           |                                |                                |                |
|-------------------------------------|-----------------------------|------------------------------|---------------------------|---------------------------|--------------------------------|--------------------------------|----------------|
| Frequency (MHz)                     | Ave output power ANT 1(dBm) | Ave output power ANT 2 (dBm) | 10log(1/duty cycle) ANT 1 | 10log(1/duty cycle) ANT 2 | Final output power ANT 1 (dBm) | Final output power ANT 2 (dBm) | Limits dBm / W |
| 2412                                | 17.36                       | 17.23                        | 0.02                      | 0.02                      | 17.38                          | 17.25                          | 30dBm/1W       |
| 2437                                | 17.28                       | 17.40                        | 0.02                      | 0.02                      | 17.30                          | 17.42                          | 30dBm/1W       |
| 2462                                | 17.47                       | 17.43                        | 0.02                      | 0.02                      | 17.49                          | 17.45                          | 30dBm/1W       |

| The test was performed with 802.11g |                             |                              |                           |                           |                                |                                |                |
|-------------------------------------|-----------------------------|------------------------------|---------------------------|---------------------------|--------------------------------|--------------------------------|----------------|
| Frequency (MHz)                     | Ave output power ANT 1(dBm) | Ave output power ANT 2 (dBm) | 10log(1/duty cycle) ANT 1 | 10log(1/duty cycle) ANT 2 | Final output power ANT 1 (dBm) | Final output power ANT 2 (dBm) | Limits dBm / W |
| 2412                                | 18.43                       | 18.51                        | 0.14                      | 0.14                      | 18.57                          | 18.65                          | 30dBm/1W       |
| 2437                                | 18.79                       | 18.80                        | 0.14                      | 0.14                      | 18.93                          | 18.94                          | 30dBm/1W       |
| 2462                                | 18.71                       | 18.70                        | 0.14                      | 0.14                      | 18.85                          | 18.84                          | 30dBm/1W       |

| The test was performed with 802.11n20 |                             |                              |                           |                           |                                |                                |                          |            |
|---------------------------------------|-----------------------------|------------------------------|---------------------------|---------------------------|--------------------------------|--------------------------------|--------------------------|------------|
| Frequency (MHz)                       | Ave output power ANT 1(dBm) | Ave output power ANT 2 (dBm) | 10log(1/duty cycle) ANT 1 | 10log(1/duty cycle) ANT 2 | Final output power ANT 1 (dBm) | Final output power ANT 2 (dBm) | Total output power (dBm) | Limits dBm |
| 2412                                  | 18.63                       | 18.66                        | 0.15                      | 0.16                      | 18.78                          | 18.82                          | 21.81                    | 30dBm      |
| 2437                                  | 18.78                       | 18.70                        | 0.15                      | 0.16                      | 18.93                          | 18.86                          | 21.91                    | 30dBm      |
| 2462                                  | 18.71                       | 18.63                        | 0.15                      | 0.16                      | 18.86                          | 18.79                          | 21.84                    | 30dBm      |

| Operation Mode | Channel Number | Channel Frequency (MHz) | Antenna Gain (Numeric) | Power Density At 20cm (mW/cm <sup>2</sup> ) |       |       | Power Density Limit (mW/cm <sup>2</sup> ) | Test Results |
|----------------|----------------|-------------------------|------------------------|---------------------------------------------|-------|-------|-------------------------------------------|--------------|
|                |                |                         |                        | Ant 1                                       | Ant 2 | Sum   |                                           |              |
| 802.11b        | 1              | 2412                    | 1.585                  | 0.017                                       | 0.017 | --    | 1.000                                     | Pass         |
|                | 6              | 2437                    | 1.585                  | 0.017                                       | 0.017 | --    | 1.000                                     | Pass         |
|                | 11             | 2462                    | 1.585                  | 0.018                                       | 0.018 | --    | 1.000                                     | Pass         |
| 802.11g        | 1              | 2412                    | 1.585                  | 0.023                                       | 0.023 | --    | 1.000                                     | Pass         |
|                | 6              | 2437                    | 1.585                  | 0.025                                       | 0.025 | --    | 1.000                                     | Pass         |
|                | 11             | 2462                    | 1.585                  | 0.024                                       | 0.024 | --    | 1.000                                     | Pass         |
| 802.11n 20M    | 1              | 2412                    | 1.585                  | 0.024                                       | 0.024 | 0.048 | 1.000                                     | Pass         |
|                | 6              | 2437                    | 1.585                  | 0.025                                       | 0.024 | 0.049 | 1.000                                     | Pass         |
|                | 11             | 2462                    | 1.585                  | 0.024                                       | 0.024 | 0.048 | 1.000                                     | Pass         |

For 5G WIFI

| The test was performed with 802.11A |                 |                             |                              |                            |                             |                |
|-------------------------------------|-----------------|-----------------------------|------------------------------|----------------------------|-----------------------------|----------------|
| Channel                             | Frequency (MHz) | Ave output power ANT 1(dBm) | Ave output power ANT 2 (dBm) | Ave output power ANT 1(mW) | Ave output power ANT 2 (mW) | Limits dBm / W |
| Low                                 | 5180            | 15.19                       | 15.14                        | 33.04                      | 32.66                       | 24 dBm/0.25 W  |
| High                                | 5240            | 15.43                       | 15.67                        | 34.91                      | 36.90                       | 24 dBm/0.25 W  |
| Low                                 | 5745            | 12.97                       | 12.94                        | 19.82                      | 19.68                       | 30 dBm / 1 W   |
| High                                | 5825            | 11.62                       | 11.22                        | 14.52                      | 13.24                       | 30 dBm / 1 W   |

| The test was performed with 802.11N20 |                 |                             |                              |                              |                             |            |
|---------------------------------------|-----------------|-----------------------------|------------------------------|------------------------------|-----------------------------|------------|
| Channel                               | Frequency (MHz) | Ave output power ANT 1(dBm) | Ave output power ANT 2 (dBm) | Ave output Total power (dBm) | Ave output Total power (mW) | Limits dBm |
| Low                                   | 5180            | 16.55                       | 16.66                        | 19.62                        | 91.53                       | 24 dBm     |
| High                                  | 5240            | 16.83                       | 16.96                        | 19.91                        | 97.85                       | 24 dBm     |
| Low                                   | 5745            | 12.57                       | 12.84                        | 15.72                        | 37.30                       | 30 dBm     |
| High                                  | 5825            | 11.75                       | 11.66                        | 14.72                        | 29.62                       | 30 dBm     |

The test was performed with 802.11 AC(20MHz)

| Channel | Frequency (MHz) | Ave output power ANT 1(dBm) | Ave output power ANT 2 (dBm) | Ave output Total power (dBm) | Ave output Total power (mW) | Limits dBm |
|---------|-----------------|-----------------------------|------------------------------|------------------------------|-----------------------------|------------|
| Low     | 5180            | 16.63                       | 16.61                        | 19.63                        | 91.84                       | 24 dBm     |
| High    | 5240            | 16.79                       | 16.87                        | 19.84                        | 96.39                       | 24 dBm     |
| Low     | 5745            | 12.93                       | 12.99                        | 15.97                        | 39.54                       | 30 dBm     |
| High    | 5825            | 11.72                       | 11.82                        | 14.78                        | 30.06                       | 30 dBm     |

The test was performed with 802.11N40

| Channel | Frequency (MHz) | Ave output power ANT 1(dBm) | Ave output power ANT 2 (dBm) | Ave output Total power (dBm) | Ave output Total power (mW) | Limits dBm |
|---------|-----------------|-----------------------------|------------------------------|------------------------------|-----------------------------|------------|
| Low     | 5190            | 14.22                       | 14.13                        | 17.19                        | 52.31                       | 24 dBm     |
| High    | 5230            | 14.47                       | 14.48                        | 17.49                        | 56.04                       | 24 dBm     |
| Low     | 5755            | 11.85                       | 11.95                        | 14.91                        | 30.98                       | 30 dBm     |
| High    | 5795            | 11.10                       | 10.99                        | 14.06                        | 25.44                       | 30 dBm     |

The test was performed with 802.11AC(40MHz)

| Channel | Frequency (MHz) | Ave output power ANT 1(dBm) | Ave output power ANT 2 (dBm) | Ave output Total power (dBm) | Ave output Total power (mW) | Limits dBm |
|---------|-----------------|-----------------------------|------------------------------|------------------------------|-----------------------------|------------|
| Low     | 5190            | 14.78                       | 14.55                        | 17.68                        | 58.57                       | 24 dBm     |
| High    | 5230            | 14.69                       | 14.76                        | 17.74                        | 59.37                       | 24 dBm     |
| Low     | 5755            | 11.54                       | 11.68                        | 14.62                        | 28.98                       | 30 dBm     |
| High    | 5795            | 11.01                       | 11.07                        | 14.05                        | 25.41                       | 30 dBm     |

The test was performed with 802.11AC(80MHz)

| Channel | Frequency (MHz) | Ave output power ANT 1(dBm) | Ave output power ANT 2 (dBm) | Ave output Total power (dBm) | Ave output Total power (mW) | Limits dBm |
|---------|-----------------|-----------------------------|------------------------------|------------------------------|-----------------------------|------------|
| Low     | 5210            | 14.15                       | 14.16                        | 17.17                        | 52.06                       | 24 dBm     |
| High    | 5775            | 11.24                       | 11.08                        | 14.17                        | 26.13                       | 30 dBm     |

| Operation Mode | Channel Number | Channel Frequency (MHz) | Antenna Gain (Numeric) | Power Density At 20cm (mW/cm <sup>2</sup> ) |       |       | Power Density Limit (mW/cm <sup>2</sup> ) | Test Results |
|----------------|----------------|-------------------------|------------------------|---------------------------------------------|-------|-------|-------------------------------------------|--------------|
|                |                |                         |                        | Ant 1                                       | Ant 2 | Sum   |                                           |              |
| 802.11a        | 38             | 5180                    | 1.585                  | 0.010                                       | 0.010 | --    | 1.000                                     | Pass         |
|                | 46             | 5240                    | 1.585                  | 0.011                                       | 0.012 | --    | 1.000                                     | Pass         |
|                | 149            | 5745                    | 1.585                  | 0.006                                       | 0.006 | --    | 1.000                                     | Pass         |
|                | 165            | 5825                    | 1.585                  | 0.005                                       | 0.004 | --    | 1.000                                     | Pass         |
| 802.11ac 20M   | 38             | 5180                    | 1.585                  | 0.015                                       | 0.014 | 0.029 | 1.000                                     | Pass         |
|                | 46             | 5240                    | 1.585                  | 0.015                                       | 0.015 | 0.030 | 1.000                                     | Pass         |
|                | 149            | 5745                    | 1.585                  | 0.006                                       | 0.006 | 0.012 | 1.000                                     | Pass         |
|                | 165            | 5825                    | 1.585                  | 0.005                                       | 0.005 | 0.010 | 1.000                                     | Pass         |
| 802.11ac 40M   | 36             | 5190                    | 1.585                  | 0.010                                       | 0.009 | 0.019 | 1.000                                     | Pass         |
|                | 48             | 5230                    | 1.585                  | 0.009                                       | 0.009 | 0.018 | 1.000                                     | Pass         |
|                | 151            | 5755                    | 1.585                  | 0.005                                       | 0.005 | 0.010 | 1.000                                     | Pass         |
|                | 159            | 5795                    | 1.585                  | 0.004                                       | 0.004 | 0.008 | 1.000                                     | Pass         |
| 802.11n 20M    | 38             | 5180                    | 1.585                  | 0.014                                       | 0.015 | 0.029 | 1.000                                     | Pass         |
|                | 46             | 5240                    | 1.585                  | 0.015                                       | 0.016 | 0.031 | 1.000                                     | Pass         |
|                | 149            | 5745                    | 1.585                  | 0.006                                       | 0.006 | 0.012 | 1.000                                     | Pass         |
|                | 165            | 5825                    | 1.585                  | 0.005                                       | 0.005 | 0.010 | 1.000                                     | Pass         |
| 802.11n 40M    | 36             | 5190                    | 1.585                  | 0.008                                       | 0.008 | 0.016 | 1.000                                     | Pass         |
|                | 48             | 5230                    | 1.585                  | 0.009                                       | 0.009 | 0.018 | 1.000                                     | Pass         |
|                | 151            | 5755                    | 1.585                  | 0.005                                       | 0.005 | 0.010 | 1.000                                     | Pass         |
|                | 159            | 5795                    | 1.585                  | 0.004                                       | 0.004 | 0.008 | 1.000                                     | Pass         |
| 802.11ac 80M   | 42             | 5210                    | 1.585                  | 0.008                                       | 0.008 | 0.016 | 1.000                                     | Pass         |
|                | 155            | 5775                    | 1.585                  | 0.004                                       | 0.004 | 0.008 | 1.000                                     | Pass         |

For BT 4.0 LE  
GFSK mode

| Test Frequency<br>( MHz ) | Minimum Separation Distance<br>(cm) | Output Power<br>(dBm) | Output Power<br>(mW) | Target power<br>(dBm) | Antenna Gain<br>(Numeric) | Power Density Limit<br>(mW/cm <sup>2</sup> ) | Power Density At 20 cm<br>(mW/cm <sup>2</sup> ) | Test Results |
|---------------------------|-------------------------------------|-----------------------|----------------------|-----------------------|---------------------------|----------------------------------------------|-------------------------------------------------|--------------|
| 2402                      | 20.00                               | 5.92                  | 3.908                | 6 ±1                  | 1.585                     | 1.000                                        | 0.0016                                          | Pass         |
| 2440                      | 20.00                               | 6.93                  | 4.932                | 6 ±1                  | 1.585                     | 1.000                                        | 0.0016                                          | Pass         |
| 2480                      | 20.00                               | 6.94                  | 4.943                | 6 ±1                  | 1.585                     | 1.000                                        | 0.0016                                          | Pass         |

For BT classic mode  
GFSK mode

| Test Frequency<br>( MHz ) | Minimum Separation Distance<br>(cm) | Output Power<br>(dBm) | Output Power<br>(mW) | Target power<br>(dBm) | Antenna Gain<br>(Numeric) | Power Density Limit<br>(mW/cm <sup>2</sup> ) | Power Density At 20 cm<br>(mW/cm <sup>2</sup> ) | Test Results |
|---------------------------|-------------------------------------|-----------------------|----------------------|-----------------------|---------------------------|----------------------------------------------|-------------------------------------------------|--------------|
| 2402                      | 20.00                               | 6.25                  | 4.217                | 7 ±1                  | 1.585                     | 1.000                                        | 0.0020                                          | Pass         |
| 2441                      | 20.00                               | 7.46                  | 5.572                | 7 ±1                  | 1.585                     | 1.000                                        | 0.0020                                          | Pass         |
| 2480                      | 20.00                               | 7.11                  | 5.140                | 7 ±1                  | 1.585                     | 1.000                                        | 0.0020                                          | Pass         |

II/4-DQPSK Mode

| Test Frequency<br>( MHz ) | Minimum Separation Distance<br>(cm) | Output Power<br>(dBm) | Output Power<br>(mW) | Target power<br>(dBm) | Antenna Gain<br>(Numeric) | Power Density Limit<br>(mW/cm <sup>2</sup> ) | Power Density At 20 cm<br>(mW/cm <sup>2</sup> ) | Test Results |
|---------------------------|-------------------------------------|-----------------------|----------------------|-----------------------|---------------------------|----------------------------------------------|-------------------------------------------------|--------------|
| 2402                      | 20.00                               | 4.98                  | 3.148                | 5±1                   | 1.585                     | 1.000                                        | 0.0013                                          | Pass         |
| 2441                      | 20.00                               | 5.81                  | 3.811                | 5±1                   | 1.585                     | 1.000                                        | 0.0013                                          | Pass         |
| 2480                      | 20.00                               | 5.35                  | 3.428                | 5±1                   | 1.585                     | 1.000                                        | 0.0013                                          | Pass         |

8DPSK Mode

| Test Frequency<br>( MHz ) | Minimum Separation Distance<br>(cm) | Output Power<br>(dBm) | Output Power<br>(mW) | Target power<br>(dBm) | Antenna Gain<br>(Numeric) | Power Density Limit<br>(mW/cm <sup>2</sup> ) | Power Density At 20 cm<br>(mW/cm <sup>2</sup> ) | Test Results |
|---------------------------|-------------------------------------|-----------------------|----------------------|-----------------------|---------------------------|----------------------------------------------|-------------------------------------------------|--------------|
| 2402                      | 20.00                               | 5.22                  | 3.327                | 5±1                   | 1.585                     | 1.000                                        | 0.0013                                          | Pass         |
| 2441                      | 20.00                               | 5.92                  | 3.908                | 5±1                   | 1.585                     | 1.000                                        | 0.0013                                          | Pass         |
| 2480                      | 20.00                               | 5.74                  | 3.750                | 5±1                   | 1.585                     | 1.000                                        | 0.0013                                          | Pass         |

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

The device could operate simultaneously in 2.4G and 5G band, RF exposure shall be evaluated in operation mode with 2.4 and 5G on simultaneously,

We took the maximum Power Density value from 2.4 and 5G bands and added the two values to obtain a maximum Power Density value.

The maximum Power Density value= $0.049+0.031+0.002=0.082<1.000$

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

### 1.5.FCC Radiation Exposure Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. In order to avoid the possibility of exceeding the FCC radio frequency exposure limits, Human proximity to the antenna shall not be less than 20cm(8 inches) during normal operation. Proposed RF exposure safety information to include in User's Manual.