# RF EXPOSURE EVALUATION REPORT

For: Apple Inc.

**Product: A2116**

**FCC ID: BCGA2116**

**RF Exposure Evaluation Report Serial No.:**
UL/REGA1/MPE12505086B

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| **This RF Exposure Evaluation Report Is Issued Under The Authority Of Alan Binks, Head of Inspection:**<br>**PP:** | |
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| **Report Copy No: PDF01** | **Issue Date: 20 February 2019** |



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# RF Exposure Evaluation for the A2116

The A2116 is a desktop computer which contains 2.4GHz and 5GHz WIFI and 2.4GHz Bluetooth BR/ EDR and LE transmitters.

WLAN supports 3x3 MIMO operation with beam forming, and there can be simultaneous transmission between all of the transmitters.

**The following FCC Rule Parts and procedures are applicable:**

Part 1.1310 – Radiofrequency radiation exposure limits
Part 2.1091 – Radiofrequency radiation exposure evaluation: mobile devices

KDB447498 D01 v06 - Mobile and Portable Devices RF Exposure Procedures and Equipment Authorisation Policies

KDB 662911 D01 v02 r01 – Multiple Transmitter Output

## MAXIMUM TRANSMITTER POWER CONSIDERATIONS

From Tune Up tables (conducted power):

**WLAN 2.4GHz:**

**Power (SISO) = 23.0dBm max**

For non-beam forming MIMO, conducted power for each antenna:

Power (2x2MIMO) = 23.0dBm max (200mW)

Power (3x3 MIMO) = 22.0dBm max (158.5mW)

For BF MIMO:

Power (2x2MIMO) = 21.25dBm max (133.4mW)

Power (3x3MIMO) = 20.0dBm max (100.0mW)

ANTENNA GAINS:

Antenna Gain WF2: +4.32dBi (x2.7)

Antenna Gain WF3: +4.77dBi (x3.0)

Antenna Gain WF4: +3.72dBi (x2.36)

From KDB 662911 D01 v02 r01., Max. beamforming max antenna gain is calculated as:

For 2x2MIMO = +7.6dBi (x5.75)

For 3x3MIMO = +9.0dBi (x7.94)

RADIATED POWER:

**$EIRP_{SISO2}$** = 27.32dBm = 539.5 mW

**$EIRP_{SISO3}$ = 27.77dBm = 598.4 mW***

**$EIRP_{SISO4}$** = 26.72dBm = 469.9 mW

Power for non BF 2x2 MIMO operation using WF2 + WF3 antennas:

**$EIRP_{MIMO2}$** = 27.57dBm + 27.77dBm = 539.5mW + 598.4mW = 1.14W

Power for BF 2x2 MIMO operation**:**

**$EIRP_{BF2}$** = 28.85dBm = 767.4mW

Power for non BF 3x3 MIMO operation:

**$EIRP_{MIMO3}$ = 26.32dBm + 26.77dBm + 25.72dBm = 428.5mW + 475.3mW + 373.3.5mW = 1.28W***

Power for BF 3x3 MIMO operation**:**

**$EIRP_{BF3}$** = 29dBm = 794mW

***max power to be considered in calculations

**WLAN 5GHz:**

**Power = 22.0dBm max** (For SISO + 2x2 MIMO + 3x3MIMO + BF)

ANTENNA GAINS:

Antenna Gain WF2: +4.86dBi

Antenna Gain WF3: +3.21dBi

Antenna Gain WF4: +3.09dBi

From KDB 662911 D01 v02 r01., Max. beamforming max antenna gain is calculated as:

For 2x2MIMO = +7.6dBi (x5.75)

For 3x3MIMO = +9.0dBi (x7.94)

RADIATED POWER:

**$EIRP_{SISO2}$ = 26.86dBm = 485.3 mW***

$EIRP_{SISO3}$ = 25.21dBm = 331.9 mW

$EIRP_{SISO4}$ = 25.09dBm = 322.8 mW

Power for non BF 2x2 MIMO operation using WF2 + WF3 antennas:

**$EIRP_{MIMO2}$** = 26.86dBm + 25.21dBm = 485.2mW + 331.9mW = 817.1mW

Power for BF operation**:**

**$EIRP_{BF2}$** = 29.6dBm = 912mW

Power for non BF 3x3 MIMO operation:

**$EIRP_{MIMO3}$** = 26.86dBm + 25.21dBm + 25.09dBm = 485.2mW + 331.9mW + 322.8mW= 1.14W

Power for BF operation**:**

**$EIRP_{BF3}$** = **31.0dBm = 1.26W***

***max power to be considered in calculations

**Bluetooth (Basic Rate, EDR & Low Energy) 2.4GHz**

Power conducted = 13.0dBm

Antenna Gain: 3.29dBi

**EIRP = 16.29dBm = 42.56mW**

## MPE CALCULATIONS

The MPE calculation used to calculate the safe operating distance for the user is.

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

**Where** S = Power density
EIRP = Effective Isotropic Radiated Power (EIRP = P x G)
P = Conducted Transmitter Power
G = Antenna Gain (relative to an isotropic radiator)
R = distance to the centre of radiation of the antenna (20cm requirement).

**For WLAN 2.4GHz**

Values:

Transmitter frequency range = 2412 MHz to 2472MHz

Max. $EIRP_{SISO}$ = 598.4 mW

$EIRP_{MIMO}$ = 1.28W

R = 20cm

Power Density Requirement

From table 1 (b) - Limits for General Population/ Uncontrolled Exposure of FCC Rule Part 1.1310 for 2.4GHz

**$S_{req1}$ = 1.0 mW/cm$^2$**

Calculation:

$S = EIRP_{SISO} / 4 \pi R^2$

$S = 598.4/(12.56 \times 20^2)$

$S = 598.4/ (5024)$

**$S_{1\ SISO}$ = 0.12mW/ cm$^2$** (<1.0 mW/cm$^2$)

Similarly for MIMO: **$S_{1\ MIMO}$ = 0.25mW/ cm$^2$** (<1.0 mW/cm$^2$)

**This equates to minimum safe operating distance ( 3x3 MIMO operation) of 10.1 cm at the RF exposure limit of 1.0 mW/cm$^2$**

**For WLAN 5GHz**

Values:

Transmitter frequency range = 5150 MHz to 5850MHz

Max. $EIRP_{SISO}$ = 485.3 mW

$EIRP_{BF}$ = 1.26W

R = 20cm

Power Density Requirement

From table 1 (b) - Limits for General Population/ Uncontrolled Exposure of FCC Rule Part 1.1310 for 5GHz

**$S_{req2}$ = 1.0 mW/cm$^2$**

Calculation:

$S = EIRP_{SISO} / 4 \pi R^2$

$S = 485.3/(12.56 \times 20^2)$

$S = 485.3/(5024)$

**$S_{2\ SISO}$ = 0.096mW/ cm$^2$** (<1.0 mW/cm$^2$)

Similarly for BF: **$S_{2\ BF}$ = 0.25mW/ cm$^2$** (<1.0 mW/cm$^2$)

**This equates to minimum safe operating distance (3x3 BF operation) of 10.0 cm at the RF exposure limit of 1.0 mW/cm$^2$**

**For Bluetooth 2.4 GHz**

Values:

Transmitter frequency range = 2402 MHz to 2480MHz

EIRP = 42.56 mW

R = 20cm

Power Density Requirement

From table 1 (b) - Limits for General Population/ Uncontrolled Exposure of FCC Rule Part 1.1310 for 5GHz

$\mathbf{S_{req3}}$ = 1.0 mW/cm$^2$

Calculation:

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

$S = 42.56/(12.56 \times 20^2)$

$S = 42.56/(5024)$

**$S_3$ = 0.0085mW/ cm$^2$** (<1.0 mW/cm$^2$)

**This equates to a minimum safe operating distance of 1.84cm at the RF exposure limit of 1.0 mW/cm$^2$**

**KDB447498 D01 v05 Section 7.2 SIMULTANEOUS TRANSMISSION CONSIDERATIONS**

Worst case summation of calculated MPE ratios for 2.4GHz/ 5GHz WLAN and 2.4GHz BT simultaneously transmitting transmitters from each respective antenna is:

**ie: $\Sigma MPE_{ratios} = (S_{1\ SISO}/ S_{req1}) + (S_{2\ SISO}/ S_{req2}) + (S_{3\ SISO}/ S_{req3})$**

$= (0.12/1.0) + (0.096/1.0) + (0.0085/1.0)$

**= 0.22**

$\Sigma$ of MPE ratios<1.0, so in accordance with KDB447498 Section 7.2, simultaneous transmission test exclusion applies for the WLAN and Bluetooth transmitters.

## Conclusion

The required 20cm RF exposure limits for General Population/ Uncontrolled Exposure will not be exceeded for the A2116 using antennas as specified.