



RF EXPOSURE EVALUATION REPORT

For: Apple Inc.

Product: A1989 MacBook Pro

FCC ID: BCGA1989

RF Exposure Evaluation Report Serial No.:
UL/REGA1/MPE12173937B

This RF Exposure Evaluation Report Is Issued Under The Authority Of Alan Binks, Head of Inspection:	
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RF Exposure Evaluation for the A1989 MacBook Pro

The A1989 is a portable computer which contains 2.4GHz and 5GHz WIFI and 2.4GHz Bluetooth BR/EDR and LE transmitters.

WLAN supports 3x3 MIMO operation, 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

MAXIMUM TRANSMITTER POWER (Tune Up max. power values)

WLAN 2.4GHz:

Power conducted = 23.0 dBm max (SISO)
= 21.0 dBm max (3x3 MIMO)

Antenna Gain WF1: +2.3 dBi

Antenna Gain WF2: +3.3 dBi

Antenna Gain WF3: +2.0 dBi

$EIRP_{SISO1} = 25.3 \text{ dBm} = 338.8 \text{ mW}$

$EIRP_{SISO2} = 26.3 \text{ dBm} = 426.6 \text{ mW}$

$EIRP_{SISO3} = 25.0 \text{ dBm} = 316.2 \text{ mW}$

$EIRP_{MIMO1} = 23.3 \text{ dBm} = 213.8 \text{ mW}$

$EIRP_{MIMO2} = 24.3 \text{ dBm} = 269.2 \text{ mW}$

$EIRP_{MIMO3} = 23.0 \text{ dBm} = 200.0 \text{ mW}$

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WLAN 5GHz:

Power conducted = 22.0 dBm max (SISO) - UNII 3 (worst case)

= 22.0 dBm max (3x3 MIMO) UNII 3 (worst case)

Antenna Gain WF1: +4.6 dBi UNII 3

Antenna Gain WF2: +5.2 dBi UNII 3

Antenna Gain WF3: +4.5 dBi UNII 3

$EIRP_{SISO1} = 26.6\text{dBm} = 457\text{mW}$

$EIRP_{SISO2} = 27.2\text{dBm} = 524.8\text{ mW}$

$EIRP_{SISO3} = 26.5\text{dBm} = 446.7\text{ mW}$

$EIRP_{MIMO1} = 26.6\text{dBm} = 457\text{mW}$

$EIRP_{MIMO2} = 27.2\text{dBm} = 524.8\text{ mW}$

$EIRP_{MIMO3} = 26.5\text{dBm} = 446.7\text{ mW}$

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

Power conducted = 13.0 dBm

Antenna Gain: 2.3 dBi

$EIRP = 15.3\text{dBm} = 33.9\text{ mW}$

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 ($EIRP = P \times G$)

P = Conducted Transmitter Power

G = Antenna Gain (relative to an isotropic radiator)

R = distance to the centre of radiation of the antenna (20cm requirement).

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For WLAN 2.4GHz

Values:

Transmitter frequency range = 2412 MHz to 2472MHz

Max. EIRP_{SISO} = 426.6 mW

EIRP_{MIMO} = 269.2 mW

R = 20cm

Power Density Requirement

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

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

Calculation:

$$S = \text{EIRP}_{\text{SISO}} / 4 \pi R^2$$

$$S = 426.6 / (12.56 \times 20^2)$$

$$S = 426.6 / (5024)$$

$$S_{1 \text{ SISO}} = 0.085 \text{ mW/cm}^2 (<1.0 \text{ mW/cm}^2)$$

Similarly for MIMO: $S_{1 \text{ MIMO}} = 0.054 \text{ mW/cm}^2 (<1.0 \text{ mW/cm}^2)$

This equates to minimum safe operating distance (SISO operation) of 5.83cm at the RF exposure limit of 1.0 mW/cm²

For WLAN 5GHz

Values:

Transmitter frequency range = 5150 MHz to 5850MHz

Max. EIRP_{SISO} = 524.8 mW - UNII 3 (worst case)

EIRP_{MIMO} = 524.8 mW - UNII 3 (worst case)

R = 20cm

Power Density Requirement

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

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

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Calculation:

$$S = \text{EIRP}_{\text{SISO}} / 4 \pi R^2$$

$$S = 524.8 / (12.56 \times 20^2)$$

$$S = 524.8 / (5024)$$

$$S_{2 \text{ SISO}} = 0.104 \text{ mW/cm}^2 (<1.0 \text{ mW/cm}^2)$$

Similarly for MIMO: $S_{2 \text{ MIMO}} = 0.104 \text{ mW/cm}^2 (<1.0 \text{ mW/cm}^2)$

This equates to minimum safe operating distance (SISO)/ MIMO operation) of 6.46 cm at the RF exposure limit of 1.0 mW/cm²

For Bluetooth 2.4 GHz

Values:

Transmitter frequency range = 2402 MHz to 2480MHz

EIRP = 33.9 mW

R = 20cm

Power Density Requirement

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

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

Calculation:

$$S = \text{EIRP} / 4 \pi R^2$$

$$S = 33.9 / (12.56 \times 20^2)$$

$$S = 33.9 / (5024)$$

$$S_3 = 0.007 \text{ mW/cm}^2 (<1.0 \text{ mW/cm}^2)$$

This equates to a safe operating distance of 1.64cm at the RF exposure limit of 1.0 mW/cm²

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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:

$$\begin{aligned}\text{ie: } \sum \text{MPE}_{\text{ratios}} &= (\text{S}_1 \text{ SISO} / \text{S}_{\text{req1}}) + (\text{S}_2 \text{ SISO} / \text{S}_{\text{req2}}) + (\text{S}_3 \text{ SISO} / \text{S}_{\text{req3}}) \\ &= (0.054/1.0) + (0.104/1.0) + (0.007/1.0) \\ &= \mathbf{0.165}\end{aligned}$$

\sum 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 A1989 MacBook Pro using antennas having a maximum gain of +3.3dBi for 2.4 WLAN, +5.2dBi for 5 GHz WLAN UNII 3, and +2.3dBi for, Bluetooth operation.
