EDCS – 16403088

Maximum Permissible Exposure Study - Engineering Analysis

C9115AXI-B

(Dual Band WLAN, BLE)

FCC ID: LDKSLTSP1905

2400-2483.5 MHz, 5150-5250 MHz,

5250-5350 MHz, 5470-5725 MHz, 5725-5850 MHz

Against the following Specifications:
47 Code of Federal Regulations 2.1091

Cisco Systems
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This report replaces any previously entered test report under EDCS – 16403088. This test report has been electronically authorized and archived using the CISCO Doc Central. Test Report Template EDCS# 11556830.

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Attestation Statement of Compliance

The C9115AXI-B has been evaluated for Maximum Permissible Exposure in compliance with 47 Code of Federal Regulations [Part 1.1307(b) (for fixed devices), Part 2.1091 (for mobile devices), and Part 2.1093 (for portable devices)]. Part 1.1307(b) refers to limits in Part 1.1310 and 2.1093. The evaluation was in accordance with methodology as referenced in KDB 447498 D01 General RF Exposure Guidance v06. This report serves as the additional technical analysis of the Cisco radio modules.

This study addresses the following transmitters using the data derived in these test reports:

- BLE report EDCS# 15596102
- 2.4GHz DTS report EDCS# 15596105
- 5GHz UNII-1 report EDCS# 15596106
- 5GHz UNII-2 report EDCS# 15596108
- 5GHz UNII-2ext report EDCS# 15596109
- 5GHz UNII-3 report EDCS# 15596110

The limits used for this evaluation are in line with the recommendations of the World Health Organizations (WHO) International Committee on Non-Ionizing Radiation Protection (ICNIRP) as well as the American National Standards Institute (ANSI) C95.1.

The limits chosen are of General Population/Uncontrolled Exposure.

The following case scenarios were used:

- BLE
- 2.4GHz WLAN
- 5GHz WLAN

This device must be installed to provide a separation distance of at least 20 cm from all persons. Installers must be provided with antenna installation and transmitter operating conditions for satisfying RF exposure compliance.

Based on the study this case scenario, the General Population/Uncontrolled Exposure and the minimum recommended distance is around 20cm (8 inches) from the antenna.

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1.0 EUT Description

The C9115AXI is a next generation access point. The dual band 2.4GHz and 5GHz WIFI radio supports the next generation WIFI protocol of 802.11ax and is backwards compatible with 802.11a, b, g, n, ac. The access point features 4 internal antennas and operates in a 4x4 configuration in both the 2.4GHz and 5GHz bands.

The C9115AXI-B Supports the following radio modes:

802.11b
802.11g
802.11a
Duplicate mode NonHT40
Duplicate mode NonHT80
Duplicate mode NonHT160
802.11n20
802.11n40
802.11ac20
802.11ac40
802.11ac80
802.11ac160
802.11ax20
802.11ax40
802.11ax80
802.11ax160

The following antennas are supported by this product series.
The data included in this report represent the worst case data for all antennas.

Frequency	Part Number	Antenna Type	Antenna Gain (dBi)
2.4GHz / 5GHz	(A antenna port)	Dual Band Omnidirectional	2.3 / 4.1
2.4GHz / 5GHz	(B antenna port)	Dual Band Omnidirectional	2.6 / 4.2
2.4GHz / 5GHz	(C antenna port)	Dual Band Omnidirectional	2.2 / 4.4
2.4GHz / 5GHz	(D antenna port)	Dual Band Omnidirectional	2.4 / 4.2

2.0 Methodology

All calculations were made in accordance with ANSI C95.1.

Measurement Uncertainty Values

Parameter	Max MU from standard	Declared MU
Occupied Channel Bandwidth	+/- 5%	+/-2%
RF Output Power, conducted	+/- 1,5dB	+/-1.4dB
Power Spectral Density, conducted	+/- 3dB	+/- 2dB
Unwanted emissions, conducted	+/- 3dB	+/- 2dB
All emissions, radiated	+/- 6dB	+/- 3.2dB
Temperature	+/- 3C	+/- 0.7C
Supply Voltages	+/- 3%	+/- 2.5%
Time	+/- 5%	+/-2%

3.0 Technical Requirements

3.1 Single Band Operation – Limits

FCC Limits for Maximum Permissible Exposure (MPE)

(A) Limits for Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
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
300-1500	--	--	f/300	6
1500-100,000	--	--	5	6

(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^2)	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	($180/f^2$)*	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

NOTE 1: See Section 1 for discussion of exposure categories.

NOTE 2: The averaging time for General Population/Uncontrolled exposure to fixed transmitters is not applicable for mobile and portable transmitters. See 47 CFR §§2.1091 and 2.1093 on source-based time-averaging requirements for mobile and portable transmitters.

4.0 Calculations

Given

E=√(30*P*G)/d and S=E^2/3770

where

E=Field Strength in Volts/meter
P=Power in Watts
G=Numeric Antenna Gain
d=Distance in meters
S=Power Density in mW/cm^2

Combine equations and rearrange the terms to express the distance as a function of the remaining variables:

d=√((30*P*G)/(3770*S))

Changing to units of power in mW and distance in cm, using:

P(mW)=P(W)/1000 d(cm)=100*d(m)

yields

d=100*√((30*(P/1000)*G)/(3770*S))
d=0.282*√(P*G/S)

where

d=Distance in cm
P=Power in mW
G=Numeric Antenna Gain
S=Power Density in mW/cm^2

Substituting the logarithmic form of power and gain using:

P(mW)=10^(P(dBm)/10) G(numeric)=10^(G(dBi)/10)

yields

d=0.282*10^((P+G)/20)/√S Equation (1)

and

s=((0.282*10^((P+G)/20))/d)^2 Equation (2)

where

d=MPE distance in cm
P=Power in dBm
G=Antenna Gain in dBi
S=Power Density in mW/cm^2

5.0 Results

Equation (1) and the measured peak power are used to calculate the MPE distance. Note that for mobile or fixed location transmitters such as an access point, the minimum separation distance is 20 cm even if the calculations indicate that the MPE distance may be less.

S=1mW/cm^2 maximum. Using the peak power levels recorded in the test report along with Equation 1 above, the MPE distances are calculated as follows.

MPE Calculations:

Frequency (MHz)	Power Density (mW/cm^2)	Radiated Transmit Power (dBm)	Antenna Gain (dBi)	MPE Distance (cm)	Limit (cm)	Margin (cm)
BLE	0.001	5.3	3	0.73	20	19.27
2.4GHz DTS	0.366	23.65	9*	12.10	20	7.90
UNII-1	0.428	22.93	10.40*	13.08	20	6.92
UNII-2	0.099	22.55	4.40*	6.28	20	13.72
UNII-2e	0.105	22.82	4.40*	6.48	20	13.52
UNII-3	0.541	23.95	10.40*	14.71	20	5.29

*Correlated Gain

To maintain compliance, installations will assure a separation distance of at least 20 cm.

Using Equation 2, the MPE levels (s) at 20 cm are calculated as follows:

Frequency (MHz)	MPE Distance (cm)	Radiated Transmit Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)	Limit (mW/cm^2)	Margin (mW/cm^2)
BLE	20	5.3	3	0.001	1	0.999
2.4GHz DTS	20	23.65	9*	0.366	1	0.63
UNII-1	20	22.93	10.40*	0.428	1	0.57
UNII-2	20	22.55	4.40*	0.099	1	0.90
UNII-2e	20	22.82	4.40*	0.105	1	0.90
UNII-3	20	23.95	10.40*	0.541	1	0.46

***** Correlated Gain

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Calculations with additional transmitters

The FCC's MPE limits vary with frequency. Therefore, in mixed or broadband RF fields where several sources and frequencies are involved, the fraction of the recommended limit (in terms of power density or square of the electric or magnetic field strength) incurred within each frequency interval should be determined, and the sum of all fractional contributions should not exceed 1.0, or 100% in terms of percentage.

Worst Case Scenario:
BLE (Highest power)
2.4GHz WLAN (Highest power)
5GHz WLAN (Highest power)

Total Power Densities (Percentages) = 2.4GHz Power Density % + 5GHz Power Density %
+ BLE Power Density %

Total Relative Power Densities (Percentages) = (0.366/1.0)*100 + (0.54/1.0)*100 + (0.001/1)*100 +
= 36.6 % + 54.1 % + 0.1%
= 90.8%

Distance (estimate) = 20* $\sqrt{\%}$ = 20*(0.908)^0.5 = 19.06 cm

The calculated separation distance of 19.06 cm is less than the 20 cm recommended distance.

The configuration above co-location calculation is for General Population/Uncontrolled exposure. The minimum distance recommended is 20 cm (8 inches) when all antennas are within 20 cm of each other.

References

American National Standards Institute (ANSI), "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," ANSI/IEEE C95.1-1992 (previously issued as IEEE C95.1-1991). Copyright 1992 by the Institute of Electrical and Electronics Engineers, Inc. (IEEE), New York, N.Y. 10017. For copies contact the IEEE: 1-800-678-4333 or 1-908-981-1393.

American National Standards Institute (ANSI), "Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave". ANSI/IEEE C95.3-1992. Copyright 1992, The Institute of Electrical and Electronics Engineers, Inc. (IEEE), New York, NY 10017. For copies contact the IEEE: 1-800-678-4333 or 1-908-981-1393.