EDCS – 22609799

Maximum Permissible Exposure Study - Engineering Analysis

C9124AXE-B

Cisco Catalyst C9124AX Series 802.11ax Access Point

FCC ID: LDK-ETHIK2360

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
170 West Tasman Drive
San Jose, CA 95134

Author: Johanna Knudsen, Nathan Sousa **Tested By:** Johanna Knudsen, Julian Land, Mathew Blackburn	**Approved By:** Sam Kim **Title:** Manager, Radio Compliance **Revision:** 1

This report replaces any previously entered test report under EDCS – 22609799. This test report has been electronically authorized and archived using the CISCO Doc Central. Test Report Template EDCS# 11556830.

EDCS – 22609799

Attestation Statement of Compliance

The C9124AXE-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- 22608350
- 2.4GHz reports:
  - EDCS- 22608351, EDCS- 22608352, EDCS- 22608355, EDCS-22608356, EDCS-22608357
- 2.4GHz Auxiliary report:
  - EDCS- 22608348
- 5GHz Primary UNII-1 reports:
  - EDCS- 22656174, EDCS- 22656194, EDCS- 22656206, EDCS- 22656207
- 5GHz Primary UNII-2 reports:
  - EDCS- 22656175, EDCS- 22656199, EDCS-22656200, EDCS-22656204
- 5GHz Primary UNII-2ext reports: E
  - DCS-22656176, EDCS-22668496, EDCS-22668499, EDCS-22668500
- 5GHz Primary UNII-3 reports:
  - EDCS-22656177, EDCS-22670414, EDCS-22670416, EDCS-22670420
- 5GHz Secondary UNII-1 reports:
  - EDCS- 22608393, EDCS- 22660080, EDCS- 22660088, EDCS- 22660090
- 5GHz Secondary UNII-2 reports:
  - EDCS- 22608396, EDCS- 22660117, EDCS-22660119, EDCS-22660204
- 5GHz Secondary UNII-2ext reports:
  - EDCS-22608402, EDCS-22660205, EDCS-22660206, EDCS-22660213
- 5GHz Secondary UNII-3 reports:
  - EDCS-22608403, EDCS-22660217, EDCS-22660219, EDCS-22660220
- 5GHz UNII-1 Auxiliary reports:
  - EDCS- 22608362
- 5GHz UNII-2 Auxiliary reports
  - EDCS- 226083625
- 5GHz UNII-2ext Auxiliary reports
  - EDCS- 22608366
- 5GHz UNII-3 Auxiliary reports
  - EDCS- 22608367

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 Primary WLAN
- 5GHz Secondary WLAN
- 2.4GHz Auxiliary Radio
- 5GHz Auxiliary Radio

This device must be installed to provide a separation distance of at least 35 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 35cm from the antenna.

1.0 EUT Description

The Cisco Catalyst 9124AX Series outdoor access points are next-generation Wi-Fi 6 access points encased in a rugged and robust design that service providers and enterprises can easily deploy.

The C9124AXE-B Supports the following radio modes:

BLE 5.1

2.4GHz Wi-Fi Radio

802.11b - Legacy CCK, One Antenna, 1 to 11 MB/s
802.11b - Legacy CCK, Two Antennas, 1 to 11 MB/s
802.11b - Legacy CCK, Three Antennas, 1 to 11 MB/s
802.11b - Legacy CCK, Four Antennas, 1 to 11 MB/s

802.11g - Non HT20, One Antenna, 6 to 54 Mbps, 1ss
802.11g - Non HT20, Two Antennas, 6 to 54 Mbps, 1ss
802.11g - Non HT20, Three Antennas, 6 to 54 Mbps, 1ss
802.11g - Non HT20, Four Antennas, 6 to 54 Mbps, 1ss

802.11g - Non HT20 Beam Forming, Two Antennas, 6 to 54 Mbps, 1ss
802.11g - Non HT20 Beam Forming, Three Antennas, 6 to 54 Mbps, 1ss
802.11g - Non HT20 Beam Forming, Four Antennas, 6 to 54 Mbps, 1ss

802.11n/ac - HT/VHT20, One Antenna, M0 to M7, 1ss
802.11n/ac - HT/VHT20, Two Antennas, M0 to M7, 1ss
802.11n/ac - HT/VHT20, Two Antennas, M8 to M15, 2ss
802.11n/ac - HT/VHT20, Three Antennas, M0 to M7, 1ss
802.11n/ac - HT/VHT20, Three Antennas, M8 to M15, 2ss
802.11n/ac - HT/VHT20, Three Antennas, M16 to M23, 3ss
802.11n/ac - HT/VHT20, Four Antennas, M0 to M7, 1ss
802.11n/ac - HT/VHT20, Four Antennas, M8 to M15, 2ss
802.11n/ac - HT/VHT20, Four Antennas, M16 to M23, 3ss
802.11n/ac - HT/VHT20, Four Antennas, M24 to M31, 4ss

802.11n/ac - HT/VHT20 Beam Forming, Two Antennas, M0 to M7, 1ss
802.11n/ac - HT/VHT20 Beam Forming, Two Antennas, M8 to M15, 2ss
802.11n/ac - HT/VHT20 Beam Forming, Three Antennas, M0 to M7, 1ss
802.11n/ac - HT/VHT20 Beam Forming, Three Antennas, M8 to M15, 2ss
802.11n/ac - HT/VHT20 Beam Forming, Three Antennas, M16 to M23, 3ss
802.11n/ac - HT/VHT20 Beam Forming, Four Antennas, M0 to M7, 1ss
802.11n/ac - HT/VHT20 Beam Forming, Four Antennas, M8 to M15, 2ss
802.11n/ac - HT/VHT20 Beam Forming, Four Antennas, M16 to M23, 3ss
802.11n/ac - HT/VHT20 Beam Forming, Four Antennas, M24 to M31, 4ss

802.11n/ac - HT/VHT20 STBC, Two Antennas, M0 to M7, 2ss
802.11n/ac - HT/VHT20 STBC, Three Antennas, M0 to M7, 2ss
802.11n/ac - HT/VHT20 STBC, Four Antennas, M0 to M7, 2ss

802.11ax - HE20, One Antenna, M0 to M9 1ss
802.11ax - HE20, Two Antennas, M0 to M9 1ss
802.11ax - HE20, Two Antennas, M0 to M9 2ss
802.11ax - HE20, Three Antennas, M0 to M9 1ss
802.11ax - HE20, Three Antennas, M0 to M9 2ss
802.11ax - HE20, Three Antennas, M0 to M9 3ss
802.11ax - HE20, Four Antennas, M0 to M9 1ss
802.11ax - HE20, Four Antennas, M0 to M9 2ss
802.11ax - HE20, Four Antennas, M0 to M9 3ss
802.11ax - HE20, Four Antennas, M0 to M9 4ss

802.11ax - HE20 Beam Forming, Two Antennas, M0 to M9 1ss
802.11ax - HE20 Beam Forming, Two Antennas, M0 to M9 2ss
802.11ax - HE20 Beam Forming, Three Antennas, M0 to M9 1ss
802.11ax - HE20 Beam Forming, Three Antennas, M0 to M9 2ss
802.11ax - HE20 Beam Forming, Three Antennas, M0 to M9 3ss
802.11ax - HE20 Beam Forming, Four Antennas, M0 to M9 1ss
802.11ax - HE20 Beam Forming, Four Antennas, M0 to M9 2ss
802.11ax - HE20 Beam Forming, Four Antennas, M0 to M9 3ss
802.11ax - HE20 Beam Forming, Four Antennas, M0 to M9 4ss

802.11ax - HE20 STBC, Two Antennas, M0 to M9 2ss
802.11ax - HE20 STBC, Three Antennas, M0 to M9 2ss
802.11ax - HE20 STBC, Four Antennas, M0 to M9 2ss

2.4GHz Auxiliary Radio
802.11g Non HT20, One Antenna, 6 to 54 Mbps, 1ss

5GHz Wi-Fi Radio:
802.11a non-HT20 (6 – 54 Mbps)
802.11a non-HT20 Beam Forming (6 – 54 Mbps)
802.11n/ac HT/VHT20 (MCS0 – MCS15)
802.11n/ac HT/VHT20 Beam Forming (MCS0 – MCS15)
802.11n/ac HT/VHT20 STBC (MCS0 – MCS7)
802.11ax HE20 (MCS0 – MCS9) 1 SS
802.11ax HE20 (MCS0 – MCS9) 2 SS
802.11ax HE20 Beam Forming (MCS0 – MCS9) 1 SS
802.11ax HE20 Beam Forming (MCS0 – MCS9) 2 SS
802.11ax HE20 STBC (MCS0 – MCS9) 2 SS

802.11a non-HT40 (6 – 54 Mbps)
802.11n/ac HT/VHT40 (MCS0 – MCS15)
802.11n/ac HT/VHT40 Beam Forming (MCS0 – MCS15)
802.11n/ac HT/VHT40 STBC (MCS0 – MCS7)
802.11ax HE40 (MCS0 – MCS9) 1 SS
802.11ax HE40 (MCS0 – MCS9) 2 SS
802.11ax HE40 Beam Forming (MCS0 – MCS9) 1 SS
802.11ax HE40 Beam Forming (MCS0 – MCS9) 2 SS
802.11ax HE40 STBC (MCS0 – MCS9) 2 SS

802.11a non-HT80 (6 – 54 Mbps)
802.11n/ac HT/VHT80 (MCS0 – MCS9) 1 SS

802.11n/ac HT/VHT80 (MCS0 – MCS9) 2 SS
802.11n/ac HT/VHT80 Beam Forming (MCS0 – MCS9) 1 SS
802.11n/ac HT/VHT80 Beam Forming (MCS0 – MCS9) 2 SS
802.11n/ac HT/VHT80 STBC (MCS0 – MCS9) 1 SS
802.11ax HE80 (MCS0 – MCS9) 1 SS
802.11ax HE80 (MCS0 – MCS9) 2 SS
802.11ax HE80 Beam Forming (MCS0 – MCS9) 1 SS
802.11ax HE80 Beam Forming (MCS0 – MCS9) 2 SS
802.11ax HE80 STBC (MCS0 – MCS9) 1 SS

5GHz Auxiliary Radio:
802.11a - Non HT20, One Antenna, 6 to 54 Mbps, 1ss

The following antennas are supported by this product series. Please note, the antenna information has been provided by the customer (the Cisco business unit). The data included in this report represent the worst-case data for all antennas.

Model C9124AXE-x Supported Antenna Gains

Frequency	Antenna Type	Antenna Gain
2.4GHz (Wi-Fi & AUX)	TX/RX: external	4dBi@2.4GHz
2.4GHz (Wi-Fi & AUX)	TX/RX: external	5dBi@2.4GHz
2.4GHz (Wi-Fi & AUX)	TX/RX: external	6dBi@2.4GHz
2.4GHz (Wi-Fi & AUX)	TX/RX: external	8dBi@2.4GHz
2.4GHz (Wi-Fi & AUX)	TX/RX: external	13dBi@2.4GHz
BLE	TX/RX: internal	5dBi

Frequency	Antenna Type	Antenna Gain
5GHz (Primary & Secondary Wi-Fi and AUX)	TX/RX: external	7dBi (Side Lobe: -1 dBi) @5GHz
5GHz (Primary & Secondary Wi-Fi and AUX)	TX/RX: external	8dBi (Side Lobe: 5 dBi) @5GHz
5GHz (Primary & Secondary Wi-Fi and AUX)	TX/RX: external	13dBi (Side Lobe: 2 dBi) @5GHz
5GHz (Primary & Secondary Wi-Fi and AUX)	TX/RX: external	14dBi (Side Lobe: 5 dBi) @5GHz

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%

2.0 Technical Requirements

2.1 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.

3.0 Calculations

Given

$E=\sqrt{(30*P*G)}/d$ 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:

$d=\sqrt{((30*P*G)/(3770*S))}$

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

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

yields

$d=100*\sqrt{((30*(P/1000)*G)/(3770*S))}$

$d=0.282*\sqrt{(P*G/S)}$

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

$d=0.282*10^{((P+G)/20)}/\sqrt{S}$ 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

4.0 Results

MPE Calculations:
Equation (1) and the measured peak power can be used to calculate the MPE distance.

Using Equation 2, the power density levels (s) at 35 cm are calculated as follows:

C9124AXE-B

Radio Interface	Frequency (MHz)	MPE Distance (cm)	Transmit Power (dBm)	Antenna Gain (dBi)	Worst Case EIRP (dBm)	Power Density (mW/cm^2)	Limit (mW/cm^2)	Margin (mW/cm^2)
BLE	2402	35	-0.56	5	4.4	0.0002	1	0.9998
2.4 GHz	2437	35	27.0	9*	36.0	0.2584	1	0.7416
2.4 GHz Auxiliary	2437	35	17.0	13	30.0	0.0649	1	0.9351
5 GHz Primary	5755	35	23.0	13	36.0	0.2579	1	0.7421
5 GHz Secondary	5785	35	26.0	10*	36.0	0.2567	1	0.7433
5 GHz Auxiliary	5785	35	18.4	14	32.4	0.1128	1	0.8872

***** Correlated Gain

To maintain compliance, installations will assure a separation distance of at least 35 cm.

EDCS – 22609799

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)
2.4GHz Auxiliary (Highest power)
5GHz WLAN Primary (Highest power)
5GHz WLAN Secondary (Highest power)
5GHz Auxiliary (Highest power)

Total Power Densities (Percentages) =

BLE Power Density %
+ 2.4GHz Power Density %
+ 2.4GHz Auxiliary Power Density %
+ 5GHz Primary Power Density %
+ 5GHz Secondary Power Density %
+ 5GHz Auxiliary Power Density %

C9124AXE-B

Total Relative Power Densities (Percentages) =

(0.0002/1.0)*100
+ (0.2584/1.0)*100
+ (0.0649/1.0)*100
+ (0.2584/1.0)*100
+ (0.2584/1.0)*100
+ (0.1128/1.0)*100
= 95.3%

The limit for this scenario is 100%. The result is passing.

With a separation distance of 35cm the worst-case co-located scenarios meet the General Population/Uncontrolled exposure Power density requirement of 1.0mW/cm^2.

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.