

EDCS- 11386277



RF Exposure Study - Engineering Analysis per

FCC 2.1091

**AIR-AP1562E-x-K9
(x=B,S,T)**

Cisco Aironet 802.11ac Dual Band Outdoor Access Points

FCC ID: LDK102103

Prepared By: Cisco Systems Inc
170 West Tasman
San Jose, CA 95134
USA

EDCS- 11386277

1.0: Attestation Statement of Compliance

The Cisco 802.11AC radio has been evaluated for Maximum Permissible Exposure in compliance with 47 Code of Federal Regulations 2.1091. The evaluation was in accordance with methodology as referenced in FCC Bulletin OET 65C (rev 01-01) along with KDB 447498 D01 General RF Exposure Guidance. This report serves as the additional technical analysis of the Cisco radio modules

This study addresses the addition of an additional pair of transmitters using the data derived in the afore mentioned report #

2.4GHz DTS report EDCS # 11346264

5GHz UNII-1 report EDCS # 11346265

5GHz UNII-2 report EDCS # 11346266

5GHz UNII-2ext reports EDCS # 11346267

5GHz UNII-3 report EDCS # 11346268

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 :

2.4GHz WLAN

5GHz WLAN

This device must be installed to provide a separation distance of at least 60 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 60cm (23.6 inches) from the antenna.

2.0 EUT Description.

The Cisco Aironet 802.11ac Radio supports the following modes of operation. The modes are further defined in the radio Theory of Operation. The modes included in this report represent the worst case data for all modes.

802.11n/ac - Non HT20, One Antenna, 6 to 54 Mbps
802.11n/ac - Non HT20, Two Antennas, 6 to 54 Mbps

802.11n/ac - HT/VHT20, One Antenna, M0 to M7
802.11n/ac - HT/VHT20, Two Antennas, M0 to M7
802.11n/ac - HT/VHT20, Two Antennas, M8 to M15

802.11n/ac - HT/VHT20 Beam Forming, Two Antennas, M0 to M7
802.11n/ac - HT/VHT20 Beam Forming, Two Antennas, M8 to M15

802.11n/ac - HT/VHT20 STBC, Two Antennas, M0 to M7

802.11n/ac - Non HT40 Duplicate, One Antenna, 6 to 54 Mbps
802.11n/ac - Non HT40 Duplicate, Two Antennas, 6 to 54 Mbps

802.11n/ac - HT/VHT40, One Antenna, M0 to M7
802.11n/ac - HT/VHT40, Two Antennas, M0 to M7
802.11n/ac - HT/VHT40, Two Antennas, M8 to M15

802.11n/ac - HT/VHT40 Beam Forming, Two Antennas, M0 to M7
802.11n/ac - HT/VHT40 Beam Forming, Two Antennas, M8 to M15

802.11n/ac - HT/VHT40 STBC, Two Antennas, M0 to M7

802.11n/ac - Non HT80 Duplicate, One Antenna, 6 to 54 Mbps
802.11n/ac - Non HT80 Duplicate, Two Antennas, 6 to 54 Mbps

802.11ac - VHT80, One Antenna, M0 to M9 1ss
802.11ac - VHT80, Two Antennas, M0 to M9 1ss
802.11ac - VHT80, Two Antennas, M0 to M9 2ss

802.11ac - VHT80 Beam Forming, Two Antennas, M0 to M9 1ss
802.11ac - VHT80 Beam Forming, Two Antennas, M0 to M9 2ss

802.11ac - VHT80 STBC, Two Antennas, M0 to M9 1ss

EDCS- 11386277

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) |
|------------------|--------------------|--|-------------------------------|
| 5 GHz | AIR-ANT5180V-N | Single Band Omni | 8 |
| | AIR-ANT5150HG-N | Horizontal Polarized Omni | 5 |
| | AIR-ANT5150VG-N | Vertical Polarized Omni | 5 |
| | AIR-ANT5114P2M-N | Single Band, Dual Polarized Directional Patch | 14 |
| 2.4/5 GHz | AIR-ANT2547V-N= | Dual-band Omni | 4 / 7 |
| | AIR-ANT2547VG-N= | Dual-band Omni, Gray | 4 / 7 |
| | AIR-ANT2568VG-N | Dual-band Omni | 6 / 8 |
| | AIR-ANT2588P3M-N= | Dual-band/Dual Polarized Directional, Patch | 8 / 8 |
| | AIR-ANT2513P4M-N | Dual-band Polarization Diverse Patch Array | 13 / 13 |

3.0 Methodology

All calculations were made in accordance with ANSI C95.1, and FCC OET 65C.

4.0 Technical Requirements

4.1 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.

5.0 Calculations

Given

$$E = \sqrt{(30 * P * G) / d} \quad \text{and} \quad S = E^2 / 3770$$

where

E=Field Strength in Volts/meter

P=Power in Watts

G=Numeric Antenna Gain

d=Distance in meters

S=Power Density in mW/cm²

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:

$$P(\text{mW}) = P(\text{W}) / 1000 \quad d(\text{cm}) = 100 * d(\text{m})$$

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/cm²

Substituting the logarithmic form of power and gain using:

$$P(\text{mW}) = 10^{(P(\text{dBm}) / 10)} \quad G(\text{numeric}) = 10^{(G(\text{dBi}) / 10)}$$

yields

$$d = 0.282 * 10^{((P + G) / 20)} / \sqrt{S} \quad \text{Equation (1)}$$

and

$$S = ((0.282 * 10^{((P + G) / 20)}) / d)^2 \quad \text{Equation (2)}$$

where

d=MPE distance in cm

P=Power in dBm

G=Antenna Gain in dBi

S=Power Density in mW/cm²

EDCS- 11386277

6.0 Results

MPE Calculations: Antennas up to 8dBi Gain

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 25 cm even if the calculations indicate that the MPE distance may be less.

S=1mW/cm² maximum. Using the peak power levels recorded in the test report along with Equation 1 above, the MPE distances are calculated as follows.

| Band | Power Density (mW/cm ²) | Peak Transmit Power (dBm) | Antenna Gain (dBi) | MPE Distance (cm) | Limit (cm) | Margin (cm) |
|--------------|-------------------------------------|---------------------------|--------------------|-------------------|------------|-------------|
| 2.4GHz DTS | 1 | 27.8 | 8 | 17.39 | 25 | 7.61 |
| 5GHz UNII-1 | 1 | 18 | 8 | 5.63 | 25 | 19.37 |
| 5GHz UNII-2 | 1 | 21 | 8 | 7.95 | 25 | 17.05 |
| 5GHz UNII-2e | 1 | 21.9 | 8 | 8.82 | 25 | 16.18 |
| 5GHz UNII-3 | 1 | 26.8 | 8 | 15.50 | 25 | 9.50 |

To maintain compliance, installations will assure a separation distance of at least 25cm. Using Equation 2, the MPE levels (s) at 25 cm are calculated as follows:

| Band | MPE Distance (cm) | Peak Transmit Power (dBm) | Antenna Gain (dBi) | Power Density (mW/cm ²) | Limit (mW/cm ²) | Margin (mW/cm ²) |
|--------------|-------------------|---------------------------|--------------------|-------------------------------------|-----------------------------|------------------------------|
| 2.4GHz DTS | 25 | 27.8 | 8 | 0.48 | 1 | 0.52 |
| 5GHz UNII-1 | 25 | 18 | 8 | 0.05 | 1 | 0.95 |
| 5GHz UNII-2 | 25 | 21 | 8 | 0.10 | 1 | 0.90 |
| 5GHz UNII-2e | 25 | 21.9 | 8 | 0.12 | 1 | 0.88 |
| 5GHz UNII-3 | 25 | 26.8 | 8 | 0.38 | 1 | 0.62 |

Calculations with additional transmitters

The Cisco 802.11ac Radio support operation with, 2.4GHz WLAN & 5GHz WLAN.

Scenerio :

2.4GHz WLAN (Highest power)

5GHz WLAN (Highest power)

TX1 + TX2 = % of standard

$$(0.48) + (0.38) = 0.86$$

$$D \text{ (estimate)} = 25 * \sqrt{\%}$$

D = 23.3cm which is less than 25cm recommended

The configuration above co-location calculation is for **General Population/Uncontrolled exposure**.

The minimum distance recommended is **25cm (9.8 inches)** for antennas upto 8dBi Gain.

MPE Calculations: Antennas greater than 8dBi up to 14dBi Gain

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 60 cm even if the calculations indicate that the MPE distance may be less.

S=1mW/cm² maximum. The highest supported antenna gain is 14dBi. Using the peak power levels recorded in the test report along with Equation 1 above, the MPE distances are calculated as follows.

MPE Calculations:

| Band | Power Density (mW/cm ²) | Peak Transmit Power (dBm) | Antenna Gain (dBi) | MPE Distance (cm) | Limit (cm) | Margin (cm) |
|--------------|-------------------------------------|---------------------------|--------------------|-------------------|------------|-------------|
| 2.4GHz DTS | 1 | 26.8 | 14 | 30.92 | 60 | 29.08 |
| 5GHz UNII-1 | 1 | 22.9 | 13 | 17.59 | 60 | 42.41 |
| 5GHz UNII-2 | 1 | 16.0 | 14 | 8.92 | 60 | 51.08 |
| 5GHz UNII-2e | 1 | 15.3 | 14 | 8.23 | 60 | 51.77 |
| 5GHz UNII-3 | 1 | 26.8 | 14 | 30.92 | 60 | 29.08 |

To maintain compliance, installations will assure a separation distance of at least 60cm.

Using Equation 2, the MPE levels (s) at 60 cm are calculated as follows:

| Band | MPE Distance (cm) | Peak Transmit Power (dBm) | Antenna Gain (dBi) | Power Density (mW/cm ²) | Limit (mW/cm ²) | Margin (mW/cm ²) |
|--------------|-------------------|---------------------------|--------------------|-------------------------------------|-----------------------------|------------------------------|
| 2.4GHz DTS | 60 | 26.8 | 14 | 0.27 | 1 | 0.73 |
| 5GHz UNII-1 | 60 | 22.9 | 13 | 0.09 | 1 | 0.91 |
| 5GHz UNII-2 | 60 | 16.0 | 14 | 0.02 | 1 | 0.98 |
| 5GHz UNII-2e | 60 | 15.3 | 14 | 0.02 | 1 | 0.98 |
| 5GHz UNII-3 | 60 | 26.8 | 14 | 0.27 | 1 | 0.73 |

Calculations with additional transmitters

The Cisco 802.11ac Radio support operation with, 2.4GHz WLAN & 5GHz WLAN.

Scenerio 1 :

2.4GHz WLAN (Highest power)

5GHz WLAN (Highest power)

$$TX1 + TX2 = \% \text{ of standard}$$

$$(0.27) + (0.27) = 0.54$$

$$D \text{ (estimate)} = 60 * \sqrt{\%}$$

D = 44.09 cm which is less than 60cm recommended

The configuration above co-location calculation is for **General Population/Uncontrolled exposure**. The minimum distance recommended is **60cm (23.6 inches)** for antennas up to 14dBi Gain.

EDCS- 11386277

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.

FCC OET 65C Evaluating Compliance with FCC Guidelines for Human Exposure to RF Fields from 9KHz to 40 Ghz