EDCS-1533190

RF Exposure Study - Engineering Analysis per

FCC 2.1091

AIR-CAP3702P-B-K9

Cisco Aironet 802.11ac Dual Band Access Points

FCC ID: LDK102087P

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1.0: Attestation Statement of Compliance

The Cisco AIR-CAP3702P-B-K9 Cisco 802.11ac Dual Band Access Point 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). 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- 1276410, 1276405, 1276387, 1276418, 1248110
5GHz UNII-1 report EDCS-1518127, 1518130, 1518133,1518136
5GHz UNII-2 report EDCS-1278285, 1395033, 1278289, 1394652, 1497904
5GHz UNII-2ext reports EDCS-1518128, 1518131, 1518134, 1518137
1278297, 1278295, 1395059
5GHz UNII-3 report EDCS-1518129, 1518132, 1518135, 1518138

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 30 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 30cm (11.8 inches) from the antenna.

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2.0 EUT Description.

The AIR-CAP3702P-B-K9 Cisco 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 HT/VHT20, One Antenna, 6 to 54 Mbps
802.11n/ac - Non HT/VHT20, Two Antennas, 6 to 54 Mbps
802.11n/ac - Non HT/VHT20, Three Antennas, 6 to 54 Mbps
802.11n/ac - Non HT/VHT20, Four Antennas, 6 to 54 Mbps

802.11n/ac - Non HT/VHT20 Beam Forming, Two Antennas, 6 to 54 Mbps
802.11n/ac - Non HT/VHT20 Beam Forming, Three Antennas, 6 to 54 Mbps
802.11n/ac - Non HT/VHT20 Beam Forming, Four Antennas, 6 to 54 Mbps

802.11n/ac - HT/VHT20, One Antenna, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT20, Two Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT20, Two Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT20, Three Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT20, Three Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT20, Three Antennas, M16 to M23, M0 to M9 3ss
802.11n/ac - HT/VHT20, Four Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT20, Four Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT20, Four Antennas, M16 to M23, M0 to M9 3ss

802.11n/ac - HT/VHT20 Beam Forming, Two Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT20 Beam Forming, Two Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT20 Beam Forming, Three Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT20 Beam Forming, Three Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT20 Beam Forming, Three Antennas, M16 to M23, M0 to M9 3ss
802.11n/ac - HT/VHT20 Beam Forming, Four Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT20 Beam Forming, Four Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT20 Beam Forming, Four Antennas, M16 to M23, M0 to M9 3ss

802.11n/ac - HT/VHT20 STBC, Two Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT20 STBC, Three Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT20 STBC, Four Antennas, M0 to M7, M0 to M9 1ss

802.11n/ac - Non HT/VHT40 Duplicate, One Antenna, 6 to 54 Mbps
802.11n/ac - Non HT/VHT40 Duplicate, Two Antennas, 6 to 54 Mbps
802.11n/ac - Non HT/VHT40 Duplicate, Three Antennas, 6 to 54 Mbps
802.11n/ac - Non HT/VHT40 Duplicate, Four Antennas, 6 to 54 Mbps

802.11n/ac - HT/VHT40, One Antenna, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT40, Two Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT40, Two Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT40, Three Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT40, Three Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT40, Three Antennas, M16 to M23, M0 to M9 3ss
802.11n/ac - HT/VHT40, Four Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT40, Four Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT40, Four Antennas, M16 to M23, M0 to M9 3ss

802.11n/ac - HT/VHT40 Beam Forming, Two Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT40 Beam Forming, Two Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT40 Beam Forming, Three Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT40 Beam Forming, Three Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT40 Beam Forming, Three Antennas, M16 to M23, M0 to M9 3ss
802.11n/ac - HT/VHT40 Beam Forming, Four Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT40 Beam Forming, Four Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT40 Beam Forming, Four Antennas, M16 to M23, M0 to M9 3ss

802.11n/ac - HT/VHT40 STBC, Two Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT40 STBC, Three Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT40 STBC, Four Antennas, M0 to M7, M0 to M9 1ss

802.11n/ac - Non HT/VHT80 Duplicate, One Antenna, 6 to 54 Mbps
802.11n/ac - Non HT/VHT80 Duplicate, Two Antennas, 6 to 54 Mbps
802.11n/ac - Non HT/VHT80 Duplicate, Three Antennas, 6 to 54 Mbps
802.11n/ac - Non HT/VHT80 Duplicate, Four Antennas, 6 to 54 Mbps

802.11n/ac - HT/VHT80, One Antenna, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT80, Two Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT80, Two Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT80, Three Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT80, Three Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT80, Three Antennas, M16 to M23, M0 to M9 3ss
802.11n/ac - HT/VHT80, Four Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT80, Four Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT80, Four Antennas, M16 to M23, M0 to M9 3ss

802.11n/ac - HT/VHT80 Beam Forming, Two Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT80 Beam Forming, Two Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT80 Beam Forming, Three Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT80 Beam Forming, Three Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT80 Beam Forming, Three Antennas, M16 to M23, M0 to M9 3ss
802.11n/ac - HT/VHT80 Beam Forming, Four Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT80 Beam Forming, Four Antennas, M8 to M15, M0 to M9 2ss
802.11n/ac - HT/VHT80 Beam Forming, Four Antennas, M16 to M23, M0 to M9 3ss

802.11n/ac - HT/VHT80 STBC, Two Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT80 STBC, Three Antennas, M0 to M7, M0 to M9 1ss
802.11n/ac - HT/VHT80 STBC, Four Antennas, M0 to M7, M0 to M9 1ss

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)	Antenna Gain >30 degrees (dBi)
2.4/5 GHz	AIR-ANT2524DB-R	Dual-resonant black dipole	2 / 4	NA
	AIR-ANT2524DW-R	Dual-resonant white dipole	2 / 4	NA
	AIR-ANT2524DG-R	Dual-resonant gray dipole	2 / 4	NA
	AIR-ANT2524V4C-R	Dual-resonant ceiling mount omni (4-pack)	2 / 4	NA
	AIR-ANT2544V4M-R8	Dual-resonant omni (4-pack)	3 / 2	1
	AIR-ANT2544V4M-R	Dual-resonant omni (4-pack)	4 / 4	1
	AIR-ANT2566P4W-R	Dual-resonant "directional" antenna (4-pack)	6 / 6	3
	AIR-ANT2566D4M-R	Dual-Band Polarization-Diverse Directional Array	6 / 6	3
	AIR-ANT2547V-N	Dual Band Omni	4 / 7	-7
	AIR-ANT2513P4M-N	Dual-resonant cross-pol "directional" antenna (4-pack)	13 / 13	-7

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=√(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

6.0 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 (7.87 inches) & 30 cm (11.8 inches) for antenna gain 10 dBi or greater, even if the calculations indicate that the MPE distance may be less.

Two RF Exposure Studies will be performed. 1) RF Exposure Study for 7dBi antenna gain , 2) RF Exposure Study for 13dBi antenna gain. This is done to show compliance to the 20cm MPE distance and 30cm MPE distance stated in user manual.

1. RF Exposure Study for 7dBi antenna gain
S=1mW/cm^2 maximum. The highest supported antenna gain is 7dBi. 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	21.2	6	6.46	20	13.54
5GHz UNII-1	1	20.5	7	6.69	20	13.31
5GHz UNII-2	1	18.2	7	5.13	20	14.87
5GHz UNII-2e	1	19.3	7	5.82	20	14.18
5GHz UNII-3	1	22.2	7	8.13	20	11.87

To maintain compliance, installations will assure a separation distance of at least 20cm.
Using Equation 2, the MPE levels (s) at 20 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	20	21.2	6	0.10	1	0.90
5GHz UNII-1	20	20.5	7	0.11	1	0.89
5GHz UNII-2	20	18.2	7	0.07	1	0.93
5GHz UNII-2e	20	19.3	7	0.08	1	0.92
5GHz UNII-3	20	22.2	7	0.17	1	0.83

Calculations with additional transmitters

The AIR-CAP3702P-B-K9 Cisco 802.11AC Radio support operation with 2.4GHz WLAN & 5GHz WLAN.

Scenerio 1 :
2.4GHz WLAN (Highest power)
5GHz WLAN (Highest power)

TX1 + TX6 = % of standard
(0.1) + (0.17) = 0.27

D (estimate) = 20* $\sqrt{\%}$

D = 10.4 cm which is less than 20cm recommended

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

2. RF Exposure Study for 13dBi antenna gain
S=1mW/cm^2 maximum. The highest supported antenna gain is 13dBi. 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	21.2	13	14.46	30	15.54
5GHz UNII-1	1	20.5	13	13.34	30	16.66
5GHz UNII-2	1	14.3	13	6.54	30	23.46
5GHz UNII-2e	1	13.9	13	6.24	30	23.76
5GHz UNII-3	1	22.2	13	16.23	30	13.77

To maintain compliance, installations will assure a separation distance of at least 40cm.

Using Equation 2, the MPE levels (s) at 40 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	30	21.2	13	0.13	1	0.77
5GHz UNII-1	30	20.5	13	0.11	1	0.80
5GHz UNII-2	30	14.3	13	0.03	1	0.95
5GHz UNII-2e	30	13.9	13	0.02	1	0.96
5GHz UNII-3	30	22.2	13	0.16	1	0.71

Calculations with additional transmitters

The AIR-CAP3702P-B-K9 Cisco 802.11AC Radio support operation with 2.4GHz WLAN & 5GHz WLAN.

Scenerio 1 :
2.4GHz WLAN (Highest power)
5GHz WLAN (Highest power)

TX1 + TX6 = % of standard
(0.13) + (0.16) = 0.29

D (estimate) = 30* $\sqrt{\%}$

D = 16.2 cm which is less than 30cm recommended

The configuration above co-location calculation is for **General Population/Uncontrolled exposure**. The minimum distance recommended is **30 cm (11.8 inches**) when all antennas are within 30cm of each other.

EDCS-1533190

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