EDCS # 24527757

Maximum Permissible Exposure Study - Engineering Analysis

IW9165E-B
IW9165E-A

Cisco Industrial Wireless Access Point

FCC ID: LDKIW9165E
IC: 2461A-IW9165E

2400-2483.5 MHz, 4.9GHz 5150-5250 MHz,

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

5925-6425MHz & 6525-6875MHz

Against the following Specifications:
47 Code of Federal Regulations 2.1091
RSS-102 Issue 5

Cisco Systems
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This report replaces any previously entered test report under EDCS 24527757. This test report has been electronically authorized and archived using the CISCO Doc Central. Test Report Template EDCS# 11556830.

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Summary of Test Result

Report Clause	Ref Std. Clause	Test Items	Result (PASS/FAIL)	Remark
2	-	Exposure evaluation	PASS	-

Declaration of Conformity:
1. The test results with all measurement uncertainty excluded are presented in accordance with the regulation limits or requirements declared by manufacturers. It's means measurement values may risk exceeding the limit of regulation standards, if measurement uncertainty is include in test results. 2. The measurement uncertainty please refer to report" Measurement Uncertainty".

1 General Description

1.1 EUT General Information

RF General Information			
Evaluation Mode	**Frequency Range (MHz)**	**Operating Frequency (MHz)**	**Modulation Type**
5GHz WLAN	5150-5250 5250-5350 5470-5725 5725-5850	5180-5250 5250-5320 5500-5720 5745-5825	802.11a/n: OFDM (BPSK, QPSK, 16QAM, 64QAM) 802.11ac: OFDM (BPSK, QPSK, 16QAM, 64QAM, 256QAM) 802.11ax: OFDMA (BPSK, QPSK, 16QAM, 64QAM, 256QAM, 1024QAM)
6GHz WLAN	5925-6425 6525-6875	5955-6415 6535-6855	802.11ax: OFDMA (BPSK, QPSK, 16QAM, 64QAM, 256QAM, 1024QAM)
4.9GHz WLAN	4940-4990	4945-4985	OFDM (BPSK, QPSK, 16QAM, 64QAM)
Bluetooth	2400-2483.5	2402-2480	LE: GFSK

1.2 Antenna Information

Part Number	Description	Peak Gain 2.4 GHz (dBi)	Peak Gain 4.9 GHz (dBi)	Peak Gain 5 GHz (dBi)	Peak Gain 6 GHz (dBi)	UNII-1 Gain above 30° elevation (dBi)	UNII-5 7 Gai above 30° elevati (dBi)
IW-ANT-PNL5615-NS	5/6 GHz two-port cross-polarized directional array with SIA	N/A	15	15	15	3	3
IW-ANT-OMM-53-N=	5 GHz 3 dBi Omnidirectional Antenna, Multi-polarized, N Female Connector	N/A	3	3	N/A	0	N/A
AIR-ANT5180V-N=	5 GHz 8 dBi Omnidirectional Colinear Array Antenna, N Male Connector	N/A	7	8	N/A	-3	N/A
IW-ANT-PNL-59-N=	5 GHz 9 dBi 2-Element Patch Array Antenna, Slant ±45 Polarized, N Female Connectors	N/A	N/A	10	N/A	7	N/A
IW-ANT-H90-510-N=	5 GHz 10 dBi 2-Element Horn Antenna, H/V Polarized, N Female Connectors	N/A	N/A	10	N/A	8	N/A
AIR-ANT5114P2M-N=	5 GHz 13 dBi 2-Element Patch Array Antenna, N Male Connectors	N/A	N/A	13	N/A	4	N/A
IW-ANT-SKD-513-Q=	5 GHz 14 dBi 2-Element Shark Antenna, Slant ±45 Polarized, QMA Female Connectors	N/A	13	13	N/A	8	N/A
IW-ANT-SKS-514-Q=	5 GHz 14 dBi 2-Element Shark Antenna, Slant ±45 Polarized, QMA Female Connectors	N/A	13	13	N/A	8	N/A
AIR-ANT2547V-N=	2.4 GHz 4 dBi / 5 GHz 7 dBi Omnidirectional Colinear Array Antenna, N male connector	4	N/A	7	N/A	-3	N/A
AIR-ANT2547VG-N=	2.4 GHz 4 dBi / 5 GHz 7 dBi Omnidirectional Colinear Array Antenna, N Male Connector	4	N/A	7	N/A	-3	N/A
AIR-ANT2547VG-NS=		4	N/A	7	N/A	-3	N/A
AIR-ANT2568VG-N=	2.4 GHz 6 dBi / 5 GHz 8 dBi Omnidirectional Antenna, N Male Connector	6	N/A	8	N/A	3	N/A
AIR-ANT2568VG-NS=		6	N/A	8	N/A	3	N/A
AIR-ANT2588P4M-NS=	2.4 GHz 8 dBi / 5 GHz 8 dBi 4-Element Dual-Polarized Patch Antenna, N Female Connectors	8	N/A	8	N/A	-2	N/A
AIR-ANT2513P4M-N=	2.4 GHz 13 dBi / 5 GHz 13 dBi Polarization Diverse Patch Array Antenna, N Female Connectors	13	N/A	13	N/A	1	N/A
AIR-ANT2513P4M-NS=		13	N/A	13	N/A	1	N/A
IW-ANT-OMV-2567-N=	Tri-band Omnidirectional Colinear Array Antenna, Vertically Polarized, N Male Connector	4	7	7	7	-9	-7
IW-ANT-OMH-2567-N=	Tri-band Omnidirectional Colinear Array Antenna, Horizontally Polarized, N Male Connector	4	7	7	7	-3	-2
IW-ANT-DS9-516-N=	5 GHz Dual Slant ±45° Polarized 90° Sector Antenna, N Female Connectors	N/A	15	15	N/A	4	N/A
IW-ANT-SS9-516-N=	5 GHz Dual H/V Polarized 90° Sector Antenna, N Female Connectors	N/A	15	15	N/A	-1	N/A

1.3 Table for EUT support function

Function	Support Band
AP	BLE, 5GHz, 6GHz ,4.9GHz
P2P/P2MP	BLE, 5GHz, 6GHz ,4.9GHz

Note1: For above table list, only AP mode was tested and recorded in this test.

Note2: The above information was declared by manufacturer.

1.4 Table for Radio function

Radio (R)	5GHz UNII 1~UNII 3	6GHz UNII 5 & UNII 7	4.9 GHz	BLE	GPS
R1	V (AP: 20/40/80) (P2P/P2MP: 20/40/80)	-	V	V	-
R2	V (AP: 20/40/80/160) (P2P/P2MP: 20/40/80/160)	V (AP: 20/40/80/160)	V	-	-
R3	-	-	-	-	V

Note: The above information was declared by manufacturer.

1.5 Applicable Standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following.

standards:

- 47 CFR Part 2.1091
- KDB 447498 D04 Interim General RF Exposure Guidance v01

The following reference test guidance is not within the scope of accreditation of TAF.

- 47 CFR Part 1.1307
- 47 CFR Part 1.1310
- RSS – 102 Issue 5

RSS – 102: IEEE C95.3-2002: *IEEE recommended practice for measurements and computations of radio frequency electromagnetic fields with respect to human exposure to such fields, 100 kHz-300 GHz*.

A device requiring an RF exposure evaluation shall be made in accordance with the latest version of IEEE C95.3

2 Maximum Permissible Exposure

2.1 MPE Exemption - FCC

Option (A): 1.1307(b)(3)(i)(A): Available maximum time-averaged power is < 1 mW.

Option (B): 1.1307(b)(3)(i)(B): Device operates between 300 MHz and 6 GHz and the maximum time-averaged power or effective radiated power (ERP), whichever is greater, <= Pth.

$$P_{th}\ (\text{mW}) = \begin{cases} ERP_{20\ cm}(d/20\ \text{cm})^{x} & d \le 20\ \text{cm} \\ ERP_{20\ cm} & 20\ \text{cm} < d \le 40\ \text{cm} \end{cases}$$

Where

$$x = -\log_{10}\left(\frac{60}{ERP_{20\ cm}\sqrt{f}}\right) \text{ and } f \text{ is in GHz;}$$

and

$$ERP_{20\ cm}\ (\text{mW}) = \begin{cases} 2040f & 0.3\ \text{GHz} \le f < 1.5\ \text{GHz} \\ 3060 & 1.5\ \text{GHz} \le f \le 6\ \text{GHz} \end{cases}$$

d = the separation distance (cm);

Option (C): 1.1307(b)(3)(i)(C): ERP is below a threshold calculated based on the distance R between the person and the antenna / radiating structure, where R > $\lambda\lambda$ / 2 TT.

Single RF Sources Subject to Routine Environmental Evaluation	
RF Source frequency (MHz)	**Threshold ERP (watts)**
0.3-1.34	1,920 R^2.
1.34-30	3,450 R^2/f^2.
30-300	3.83 R^2.
300-1,500	0.0128 R^2f.
1,500-100,000	19.2R^2.
Note: R is in meters, f is in MHz.	

Exemption Limits for Routine Evaluation - ISED RSS 102

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- below 20 MHz[6] and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $4.49/f^{0.5}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

2.2 RF exposure evaluation exemption for FCC

Radio 1: 15dBi antenna gain

Prediction frequency (MHz)	5745
Maximum Output Power (dBm)	19dBm
Maximum ERP (dBm)	31.86
Maximum ERP (W)	1.534
Prediction distance (cm)	40
1500 MHz ≤ *f* < 100000 MHz	MPE-based Exemption Threshold
	P_{th} (W)
	$19.2R^2 = 3.072W$

Radio 2: 15dBi antenna gain – 5GHz

Prediction frequency (MHz)	5745MHz
Maximum Output Power (dBm)	19dBm
Maximum ERP (dBm)	32.86
Maximum ERP (W)	1.931
Prediction distance (cm)	40
1500 MHz ≤ *f* < 100000 MHz	MPE-based Exemption Threshold
	P_{th} (W)
	$19.2R^2 = 3.072W$
OR	

Radio 2: 7dBi antenna gain – 6GHz

Prediction frequency (MHz)	6225 MHz
Maximum Output Power Antenna A (dBm)	16.70
Maximum Output Power Antenna B (dBm)	16.70
Antenna gain - Beamforming	10dBi
Maximum EIRP (dBm)	30dBm
Maximum ERP	27.86dBm
Maximum ERP (W)	0.610
Prediction distance (cm)	20
$1500\ \text{MHz} \leq f < 100000$ MHz	MPE-based Exemption Threshold
	P_{th} (W)
	$19.2R^2 = 3.072W$ $0.610W < 3.072W$

2.3 RF exposure evaluation exemption for ISED

Radio 1: 15dBi antenna gain

Prediction frequency (MHz)	5745MHz
Maximum Output Power (dBm)	19dBm
Max. Antenna gain	15dBi
Tolerances	0.50dB
Maximum EIRP (dBm)	34.50dBm
Maximum EIRP (W)	2.819
300MHz ≤ *f* < 6GHz	Exemption Limits for Routine Evaluation (W)
	1.31 x 10-2 *f*0.6834 W = 4.857 watt.

The routine evaluation is exempted because 2.819 < 4.857 watt.

Radio 2: 15dBi antenna gain

Prediction frequency (MHz)	5745MHz
Maximum Output Power (dBm)	20dBm
Max. Antenna gain	15dBi
Tolerances	0.50dB
Maximum EIRP (dBm)	35.50dBm
Maximum EIRP (W)	3.548
300MHz ≤ *f* < 6GHz	Exemption Limits for Routine Evaluation (W)
	1.31 x 10-2 *f*0.6834 W = 4.857 watt.

The routine evaluation is exempted because 3.548 < 4.857 watt.

Radio 2: 7 dBi antenna gain – 6GHz Radio

Prediction frequency (MHz)	6845 MHz
Maximum Output Power Antenna A (dBm)	11.33
Maximum Output Power Antenna B (dBm)	11.22
Antenna gain - Beamforming	15dBi
Maximum EIRP (dBm)	29.48dBm
Tolerances	0.50dB
Maximum EIRP (dBm)	29.98dBm
Maximum EIRP (W)	1W
Above 6GHz	Exemption Limits for Routine Evaluation
	5(W)
	1.122W < 5W

The routine evaluation is exempted because 1.122W < 5 watt.

2.4Limit of Maximum Permissible Exposure

(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/ cm²)	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/ cm²)	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

Note: f = frequency in MHz; *Plane-wave equivalent power density

RSS-102 limits

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m^2)	Reference Period (minutes)
0.003-10[21]	83	90	-	Instantaneous*
0.1-10	-	$0.73/ f$	-	6**
1.1-10	$87/ f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/ f^{0.25}$	$0.1540/ f^{0.25}$	$8.944/ f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142 f^{0.3417}$	$0.008335 f^{0.3417}$	$0.02619 f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/ f^{1.2}$
150000-300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

Note: f is frequency in MHz.
* Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

2.5 MPE Calculation Method

The MPE was calculated at 100 cm to show compliance with the power density limit.

The following formula was used to calculate the Power Density:

$$\text{E (V/m)} = \frac{\sqrt{30 \xi P \xi G}}{d} \qquad \text{Power Density:} \quad Pd\ (\text{W/m}^2) = \frac{E^2}{377}$$

E = Electric field (V/m)

P = RF output power (W)

G = EUT Antenna numeric gain (numeric)

d = Separation distance between radiator and human body (m)

The formula can be changed to

$$\boldsymbol{Pd} = \frac{30 \xi P \xi G}{377 \xi d^2}$$

2.6 Calculated Result and Limit

Exposure Environment: General Population / Uncontrolled Exposure

For Radio 1

For Antenna set 1 – 3dBi.

Frequency	DG (dBi)	Power (dBm)	EIRP (dBm)	Tolerance (dB)	Tune-up EIRP (dBm)	Tune-up EIRP (W)	Distance (cm)	S (mW/cm^2)	S Limit (mW/cm^2)
5220 MHz	3.0	20.9	23.9	0.50	24.40	0.275	40	0.014	1.00000
5270 MHz	3.0	24.0	27.0	0.50	27.50	0.562	40	0.028	1.00000
5500 MHz	3.0	24.0	27.0	0.50	27.50	0.562	40	0.028	1.00000
5755 MHz	**3.0**	**24.6**	**27.6**	**0.50**	**28.10**	**0.645**	**40**	**0.032**	**1.00000**
4980 MHz	3.0	15.0	18.0	0.50	18.50	0.0707	40	0.004	1.00000

For Radio 1

For Antenna set 2 – 15 dBi.

Frequency	DG (dBi)	Power (dBm)	EIRP (dBm)	Tolerance (dB)	Tune-up EIRP (dBm)	Tune-up EIRP (W)	Distance (cm)	S (mW/cm^2)	S Limit (mW/cm^2)
5220 MHz	15.0	17.0	32.0	0.50	32.50	1.22	40	0.088	1.00000
5320 MHz	15.0	12.0	27.0	0.50	27.50	0.562	40	0.028	1.00000
5660 MHz	15.0	12.0	27.0	0.50	27.50	0.562	40	0.028	1.00000
5745 MHz	**15.0**	**19.0**	**34.0**	**0.50**	**34.50**	**2.818**	**40**	**0.140**	1.00000
4950 MHz	15.0	15.0	30	0.50	30.50	1.22	40	0.056	1.00000

For Radio 1 - BLE

For Antenna – 8dBi

Frequency	DG (dBi)	Power (dBm)	EIRP (dBm)	Tolerance (dB)	Tune-up EIRP (dBm)	Tune-up EIRP (W)	Distance (cm)	S (mW/cm^2)	S Limit (mW/cm^2)
2437 MHz	8	4.5	12.5	0.50	13.0	0.020	40	0.001	1.00000

For Radio 2

For Antenna set 1 5GHz – 3dBi.

Frequency	DG (dBi)	Power (dBm)	EIRP (dBm)	Tolerance (dB)	Tune-up EIRP (dBm)	Tune-up EIRP (W)	Distance (cm)	S (mW/cm^2)	S Limit (mW/cm^2)
5240MHz – BF 2T1S	6.01	20.9	26.91	0.50	27.41	0.551	40	0.027	1.00000
5320 MHz	3.0	19.9	22.9	0.50	23.40	0.219	40	0.011	1.00000
5690 MHz	3.0	21.6	24.6	0.50	25.10	0.320	40	0.016	1.00000
5745 MHz	3.0	21.5	24.5	0.50	25.0	0.397	40	0.016	1.00000
4980 MHz	3.0	20.0	23	0.50	23.50	0.210	40	0.011	1.00000

For Radio 2

For Antenna set 2 5GHz– 15 dBi.

Frequency	DG (dBi)	Power (dBm)	EIRP (dBm)	Tolerance (dB)	Tune-up EIRP (dBm)	Tune-up EIRP (W)	Distance (cm)	S (mW/cm^2)	S Limit (mW/cm^2)
5220 MHz	15.0	17.0	32.0	0.50	32.50	1.22	40	0.088	1.00000
5320 MHz	15.0	12.0	27.0	0.50	27.50	0.562	40	0.028	1.00000
5660 MHz	15.0	12.0	27.0	0.50	27.50	0.562	40	0.028	1.00000
5745 MHz	**18.0**	**17.0**	**35.0**	**0.50**	**35.50**	**0.562**	40	**0.176**	**1.00000**
4950 MHz	15.0	15.0	30	0.50	30.50	1.22	40	0.056	1.00000

For Radio 2 – 6GHz For

Antenna gain – 15 dBi

Frequency	DG (dBi)	Power (dBm)	EIRP (dBm)	Tolerance (dB)	Tune-up EIRP (dBm)	Tune-up EIRP (W)	Distance (cm)	S (mW/cm^2)	S Limit (mW/cm^2)
6825 MHz	15	14.48	29.48	0.50	29.98	1	20	0.223	1.00000

2.7 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) – 13dBm
5GHz Radio 1 – 34.50dBm
5/6GHz Radio 2 – 35.50dBm

Total Power Densities (Percentages) = 5GHz Radio 1 Power Density % + 5GHz Radio 2 Power Density % +

BLE Power Density % + 4.9GHz Radio 1

Total Relative Power Densities (Percentages) = (0.140/1.0) *100 + (0.176/1.0) *100 + (0.001/1)*100 +
(0.056/1.0)*100=
= 14 % + 17.6 % + 1% + 5.6 %
= 38.2%

-----THE END----