RF Exposure Evaluation Declaration

FCC ID:	2AD8UFZCWO2CA1
APPLICANT:	Nokia Solutions and Networks, OY
Application Type:	Certification
Product:	AC220 Wi-Fi AP OD directional antenna US AC220 Wi-Fi AP OD external antenna US AC220 Wi-Fi AP OD small omni antenna US
Model No.:	WO2C-AC220
Trademark:	NOKIA
FCC Classification:	Digital Transmission System (DTS) Unlicensed National Information Infrastructure (UNII)
Test Procedure(s):	KDB 447498 D01v06

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Approved By : Chenz Ker
(Chenz Ker)

Testing Laboratory
3261

Revision History

Report No.	Version	Description	Issue Date	Note
1707TW0110-U3	Rev. 01	Initial Report	10-30-2017	Valid

1. PRODUCT INFORMATION

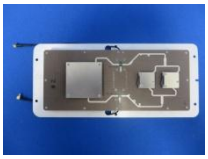
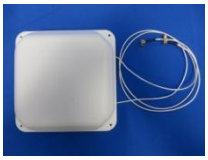
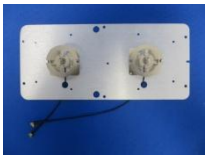
1.1. Equipment Description

Product Name	AC220 Wi-Fi AP OD directional antenna US AC220 Wi-Fi AP OD external antenna US AC220 Wi-Fi AP OD small omni antenna US
Model No.	WO2C-AC220
Brand Name	NOKIA
Hardware Version:	802.11a/b/g/n/ac
Frequency Range	**2.4GHz:** For 802.11b/g/n-HT20: 2412 ~ 2462 MHz For 802.11n-HT40: 2422 ~ 2452 MHz **5GHz:** For 802.11a/n-HT20/ac-VHT20:5180~5240MHz, 5745~5825MHz For 802.11n-HT40/ac-VHT40:5190~5230MHz, 5755~5795MHz For 802.11ac-VHT80:5210MHz, 5775MHz
Type of Modulation	802.11a/n/ac: OFDM
Modulation Technology	CCK, DQPSK, DBPSK for DSSS 16QAM, 64QAM, QPSK, BPSK for OFDM

Note: The model difference as below:

- when the device has been connected the Galtronics Directional antenna, the product name is “AC220 Wi-Fi AP OD directional antenna US”;
- when the device has been connected the PCTEL antenna, the product name is “AC220 Wi-Fi AP OD external antenna US”;
- when the device has been connected the Galtronics Small Omni antenna, the product name is “AC220 Wi-Fi AP OD small omni antenna US”;

1.2. Antenna Description

Antenna	Manufacture	Frequency Band (MHz)	Antenna Type	Part Number
	Galtronics	2412 ~ 2472 5150 ~ 5250 5725 ~ 5850	Directional Antenna	02078140-06561U2
	PCTEL, Inc.	2412 ~ 2472 5150 ~ 5850	Panel Antenna	FPMI2458-DP2RPSMA
	Galtronics	2412 ~ 2472	Small Omni Antenna	02078140-06561U1

Antenna Type	Frequency Band (MHz)	TX Paths	Per Chain Max Antenna Gain (dBi)		Beam Forming Directional Gain (dBi)	CDD Directional Gain (dBi)	
			Ant 1	Ant 2		For Power	For PSD
Directional Antenna	2412 ~ 2462	2	9.00	9.00	12.01	9.00	12.01
	5150 ~ 5250	2	11.00	11.00	14.01	11.00	14.01
	5150 ~ 5250 30°elevation angle	2	3.00	3.00	6.01	3.00	6.01
	5725 ~ 5850	2	10.00	10.00	13.01	10.00	13.01
Panel Antenna	2412 ~ 2462	2	6.00	6.00	9.01	6.00	9.01
	5150 ~ 5250	2	5.00	5.00	8.01	5.00	8.01
	5150 ~ 5250 30° elevation angle	2	2.27	2.27	5.28	2.27	N/A
	5725 ~ 5850	2	5.00	5.00	8.01	5.00	8.01
Small Omni Antenna	2412 ~ 2462	2	5.25	5.25	8.26	5.25	8.26
	5150 ~ 5250	2	6.50	6.50	9.51	6.50	9.51
	5150 ~ 5250 30°elevation angle	2	-1.25	-1.25	1.76	-1.25	1.76
	5725 ~ 5850	2	6.50	6.50	9.51	6.50	9.51

Note:

1. The EUT supports Cyclic Delay Diversity (CDD) mode, and CDD signals are correlated.
   For CDD transmissions, directional gain is calculated as follows, N_{ANT} = 2, N_{SS} = 1.

1) If all antennas have the same gain, G_{ANT}, Directional gain = G_{ANT} + Array Gain, where Array Gain is as follows.

- For power spectral density (PSD) measurements on all devices,
  Array Gain = 10 log (N_{ANT}/ N_{SS}) dB = 3.01;
- For power measurements on IEEE 802.11 devices,
  Array Gain = 0 dB for $N_{ANT} \leq 4$;

2) If antenna gains are not equal, the user may use either of the following methods to calculate directional gain, provided that each transmit antenna is driven by only one spatial stream:

- Directional gain may be calculated by using the formulas applicable to equal gain antennas with G_{ANT} set equal to the gain of the antenna having the highest gain;
- $$DirectionalGain = 10 \cdot \log \left[\frac{\sum_{j=1}^{N_{SS}} \left\{ \sum_{k=1}^{N_{ANT}} g_{j,k} \right\}^2}{N_{ANT}} \right]$$

$g_{j,k} = 10^{G_k/20}$ if the kth antenna is being fed by spatial stream j, or zero if it is not;

G_k is the gain in dBi of the kth antenna.

2. The EUT also supports Beam Forming mode, and the Beam Forming support 802.11n, not include 802.11a/ac.

Correlated signals include, but are not limited to, signals transmitted in any of the following modes:

- Any transmit Beam Forming mode, whether fixed or adaptive (e.g., phased array modes, closed loop MIMO modes, Transmitter Adaptive Antenna modes, Maximum Ratio Transmission (MRT) modes, and Statistical Eigen Beam Forming (EBF) modes).

Unequal antenna gains, with equal transmit powers. For antenna gains given by G_1, G_2, …, G_N dBi.

- transmit signals are correlated, then
- Directional gain = 10*log[($10^{G1/20}$ + $10^{G2/20}$ + … + $10^{GN/20}$)^2/N_{ANT}] dBi [Note the “20”s in the denominator of each exponent and the square of the sum of terms; the object is to combine the signal levels coherently.]

2. RF Exposure Evaluation

2.1. Limits

According to FCC 1.1310: The criteria listed in the following table shall be used to evaluate the environment impact of human exposure to radio frequency (RF) radiation as specified in 1.1307(b)

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Average Time (Minutes)
(A) Limits for Occupational/ Control Exposures				
300-1500	--	--	f/300	6
1500-100,000	--	--	5	6
(B) Limits for General Population/ Uncontrolled Exposures				
300-1500	--	--	f/1500	6
1500-100,000	--	--	1	30

f= Frequency in MHz

Calculation Formula: Pd = (Pout*G)/(4*pi*r2)

Where
Pd = power density in mW/cm^2
Pout = output power to antenna in mW
G = gain of antenna in linear scale
Pi = 3.1416
r = distance between observation point and center of the radiator in cm

Pd is the limit of MPE, $1mW/cm^2$. If we know the maximum gain of the antenna and the total power input to the antenna, through the calculation, we will know the distance r where the MPE limit is reached.

2.2. Test Result of RF Exposure Evaluation

Product Name:	AC220 Wi-Fi AP OD directional antenna US AC220 Wi-Fi AP OD external antenna US AC220 Wi-Fi AP OD small omni antenna US
Test Item	RF Exposure Evaluation (For General Population)

Directional Antenna:

Test Mode	Frequency Band (MHz)	Maximum EIRP (dBm)	Safety Distance (cm)	Power Density (mW/cm^2)	Limit of Power Density (mW/cm^2)
802.11b/g/n-HT20/ n-HT40	2412 ~ 2462	35.37	25	0.4384	1
802.11a/n-HT20/ n-H40/ac-VHT20 ac-VHT40/ac-VHT80	5150 ~ 5250	28.82	25	0.0970	1
	5725 ~ 5850	35.83	25	0.4874	1

Note: Directional Gain Calculation as below:

2412 ~ 2462MHz Directional Gain = $10*\log[(10^{9.00/20} + 10^{9.00/20})^2/2] = 12.01$ dBi

5150 ~ 5250MHz Directional Gain = $10*\log[(10^{11.00/20} + 10^{11.00/20})^2/2] = 14.01$ dBi

5725 ~ 5850MHz Directional Gain = $10*\log[(10^{10.00/20} + 10^{10.00/202}/2] = 13.01$ dBi

Panel Antenna:

Test Mode	Frequency Band (MHz)	Maximum EIRP (dBm)	Safety Distance (cm)	Power Density (mW/cm^2)	Limit of Power Density (mW/cm^2)
802.11b/g/n-HT20/ n-HT40	2412 ~ 2462	33.34	20	0.4293	1
802.11a/n-HT20/ n-H40/ac-VHT20 ac-VHT40/ac-VHT80	5150 ~ 5250	23.54	20	0.0449	1
	5725 ~ 5850	33.44	20	0.4393	1

Note: Directional Gain Calculation as below:

2412 ~ 2462MHz Directional Gain = $10*\log[(10^{6.00/20} + 10^{6.00/20})^2/2] = 9.01$ dBi

5150 ~ 5250MHz Directional Gain = $10*\log[(10^{5.00/20} + 10^{5.00/20})^2/2] = 8.01$ dBi

5725 ~ 5850MHz Directional Gain = $10*\log[(10^{5.00/20} + 10^{5.00/20})^2/2] = 8.01$ dBi

Small Omni Antenna:

Test Mode	Frequency Band (MHz)	Maximum EIRP (dBm)	Safety Distance (cm)	Power Density (mW/cm^2)	Limit of Power Density (mW/cm^2)
802.11b/g/n-HT20/ n-HT40	2412 ~ 2462	32.58	20	0.3604	1
802.11a/n-HT20/ n-H40/ac-VHT20 ac-VHT40/ac-VHT80	5150 ~ 5250	28.61	20	0.1445	1
	5725 ~ 5850	34.88	20	0.6120	1

Note: Directional Gain Calculation as below:

2412 ~ 2462MHz Directional Gain = $10*\log[(10^{5.25/20} + 10^{5.25/20})^2/2] = 8.26$ dBi

5150 ~ 5250MHz Directional Gain = $10*\log[(10^{6.50/20} + 10^{6.50/20})^2/2] = 9.51$ dBi

5725 ~ 5850MHz Directional Gain = $10*\log[(10^{6.50/20} + 10^{6.50/202}/2] = 9.51$ dBi

Product Name:	AC220 Wi-Fi AP OD directional antenna US AC220 Wi-Fi AP OD external antenna US AC220 Wi-Fi AP OD small omni antenna US
Test Item	RF Exposure Evaluation (For Occupational)

Directional Antenna:

Test Mode	Frequency Band (MHz)	Maximum EIRP (dBm)	Safety Distance (cm)	Power Density (mW/cm^2)	Limit of Power Density (mW/cm^2)
802.11b/g/n-HT20/ n-HT40	2412 ~ 2462	35.37	20	0.6851	5
802.11a/n-HT20/ n-H40/ac-VHT20 ac-VHT40/ac-VHT80	5150 ~ 5250	28.82	20	0.1516	5
	5725 ~ 5850	35.83	20	0.7616	5

Note: Directional Gain Calculation as below:

2412 ~ 2462MHz Directional Gain = $10*\log[(10^{9.00/20} + 10^{9.00/20})^2/2]$ = 12.01 dBi

5150 ~ 5250MHz Directional Gain = $10*\log[(10^{11.00/20} + 10^{11.00/20})^2/2]$ = 14.01 dBi

5725 ~ 5850MHz Directional Gain = $10*\log[(10^{10.00/20} + 10^{10.00/202}/2]$ = 13.01 dBi

Panel Antenna:

Test Mode	Frequency Band (MHz)	Maximum EIRP (dBm)	Safety Distance (cm)	Power Density (mW/cm^2)	Limit of Power Density (mW/cm^2)
802.11b/g/n-HT20/ n-HT40	2412 ~ 2462	33.34	20	0.4293	5
802.11a/n-HT20/ n-H40/ac-VHT20 ac-VHT40/ac-VHT80	5150 ~ 5250	23.54	20	0.0449	5
	5725 ~ 5850	33.44	20	0.4393	5

Note: Directional Gain Calculation as below:

2412 ~ 2462MHz Directional Gain = $10*\log[(10^{6.00/20} + 10^{6.00/20})^2/2]$ = 9.01 dBi

5150 ~ 5250MHz Directional Gain = $10*\log[(10^{5.00/20} + 10^{5.00/20})^2/2]$ = 8.01 dBi

5725 ~ 5850MHz Directional Gain = $10*\log[(10^{5.00/20} + 10^{5.00/20})^2/2]$ = 8.01 dBi

Small Omni Antenna:

Test Mode	Frequency Band (MHz)	Maximum EIRP (dBm)	Safety Distance (cm)	Power Density (mW/cm^2)	Limit of Power Density (mW/cm^2)
802.11b/g/n-HT20/ n-HT40	2412 ~ 2462	32.58	20	0.3604	5
802.11a/n-HT20/ n-H40/ac-VHT20 ac-VHT40/ac-VHT80	5150 ~ 5250	28.61	20	0.1445	5
	5725 ~ 5850	34.88	20	0.6120	5

Note: Directional Gain Calculation as below:

2412 ~ 2462MHz Directional Gain = $10*\log[(10^{5.25/20} + 10^{5.25/20})^2/2] = 8.26$ dBi

5150 ~ 5250MHz Directional Gain = $10*\log[(10^{6.50/20} + 10^{6.50/20})^2/2] = 9.51$ dBi

5725 ~ 5850MHz Directional Gain = $10*\log[(10^{6.50/20} + 10^{6.50/202}/2] = 9.51$ dBi

2.3. Summary of Test Result

The maximum calculations of above situations

Model	Configuration	The formula of calculated the MPE (mW/cm^2)	Calculation Power Density (mW/cm^2)	Limit	Result
General Population	2.4GHz + 5GHz	0.4384 + 0.4874	0.9258	1	Pass
Occupational	2.4GHz + 5GHz	0.6851 + 0.7616	1.4467	5	Pass

The wireless device described within this report has been shown to be capable of compliance with basic restrictions related to human exposure to electromagnetic fields for both General public and Occupational. The calculations shown in this report were made in accordance the procedures specified in the applied test specifications

Antenna Type	Configuration	Required Compliance Boundary (cm)	
		General Population	Occupational
Directional Antenna	2.4GHz + 5GHz	25	20
Panel Antenna	2.4GHz + 5GHz	20	20
Small Omni	2.4GHz + 5GHz	20	20

The End