RF Exposure Evaluation Declaration

FCC ID:	2AD8UFZCWMBOM2
APPLICANT:	Nokia Solutions and Networks, OY
Application Type:	Certification
Product:	AC220m Wi-Fi module OD US
Model No.:	FZCWMBOM2
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)

Revision History

Report No.	Version	Description	Issue Date	Note
1712TW0104-U8	Rev. 01	Initial Report	05-17-2018	Valid

§2.1033 General Information

Applicant:	Nokia Solutions and Networks, OY
Applicant Address:	2000 W. Lucent Lane, Naperville, Illinois, United States, 60563
Manufacturer:	Nokia Solutions and Networks, OY
Manufacturer Address:	2000 W. Lucent Lane, Naperville, Illinois, United States, 60563
Test Site:	MRT Technology (Taiwan) Co., Ltd
Test Site Address:	No. 38, Fuxing Second Rd., Guishan Dist., Taoyuan City 333, Taiwan (R.O.C)
FCC Registration No.:	153292
FCC Rule Part(s):	Part15 Subpart C (Section 15.247)
Test Device Serial No.:	N/A ☐ Production ☒ Pre-Production ☐ Engineering

Test Facility / Accreditations

Measurements were performed at MRT Laboratory located in Fuxing Rd., Taoyuan, Taiwan (R.O.C)

- **MRT facility is a FCC registered (Reg. No. 153292) test facility with the site description report on file and is designated by the FCC as an Accredited Test Film.**
- **MRT facility is an IC registered (MRT Reg. No. 21723-1) test laboratory with the site description on file at Industry Canada.**
- **MRT Lab is accredited to ISO 17025 by the American Association for Laboratory Accreditation (TAF) under the American Association for Laboratory Accreditation Program (TAF Cert. No. 3261) in EMC, Telecommunications and Radio testing for FCC, Industry Taiwan, EU and TELEC Rules.**

1. PRODUCT INFORMATION

1.1. Equipment Description

Product Name:	AC220m Wi-Fi module OD US
Model No.:	FZCWMBOM2
Brand Name:	Nokia
Wi-Fi Specification	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	802.11b: DSSS 802.11g/n/ac: OFDM
Modulation Technology	CCK, DQPSK, DBPSK for DSSS 16QAM, 64QAM, 256QAM, QPSK, BPSK for OFDM

1.2. Antenna Description

Antenna	Manufacturer	Frequency Band (GHz)	Antenna Name	Tx Paths
	Nokia	2.4	473171A / FAWH (WiFi Omni Antenna)	2
		5		2
	Nokia	2.4	474073A / FA2NB (WiFi Directional Antenna)	2
		5		2

Note: The manufacture has provided an antenna cable to connect WiFi Omni Antenna with EUT, and the cable loss is: 0.45dB Max @ 0~3 GHz; 0.75dB Max @ 0~6 GHz

Frequency Band (MHz)	TX Paths	Per Chain Max Antenna Gain (dBi)		Beam Forming Directional Gain (dBi)	CDD Directional Gain(dBi)	
		Ant 0	Ant 1		For Power	For PSD
WiFi Omni Antenna						
2412 ~ 2462	2	4.0	4.0	7.01	4.00	7.01
5150 ~ 5250	2	7.0	7.0	10.01	7.00	10.01
5150 ~ 5250 (30 Degree)	2	7.0	7.0	10.01	N/A	N/A
5250 ~ 5350	2	7.0	7.0	10.01	7.00	10.01
5470 ~ 5725	2	7.0	7.0	10.01	7.00	10.01
5725 ~ 5850	2	7.0	7.0	10.01	7.00	10.01
WiFi Directional Antenna						
2412 ~2462	2	7.7	8.5	11.12	8.5	11.51
5150 ~ 5250	2	8.3	9.5	11.93	9.5	12.51
5150 ~ 5250 (30 Degree)	2	-2.7	-3.6	-0.13	N/A	N/A
5250 ~ 5350	2	8.1	9.5	11.84	9.5	12.51
5470 ~ 5725	2	9.9	9.6	12.76	9.9	12.91
5725 ~ 5850	2	9.0	8.8	11.91	9.0	12.01

Note1: The EUT supports Cyclic Delay Diversity (CDD) technology for 802.11a/b/g mode, and CDD signals are correlated.

Note 2: The EUT supports Beam Forming technology for 802.11n/ac mode.

Note 3: For CDD transmissions, directional gain is calculated as follows, $N_{ANT} = 2$, $N_{SS} = 1$.

Two 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 $N_{ANT} \leq 4$;

Note 4: For Beam Forming transmissions, directional gain = $10*\log[(10^{G1/20} + 10^{G2/20} + \ldots + 10^{GN/20})^2/N_{ANT}]$dBi.

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/cm2
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/cm². 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	AC220m Wi-Fi module OD US
Test Item	RF Exposure Evaluation (For General Population)

Wi-Fi 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)
802.11a/n-HT20/ n-H40/ac-VHT20 ac-VHT40/ac-VHT80	5250 ~ 5350 5470 ~ 5725	29.82	24	0.1325	1

Note: Directional Gain Calculation of Maximum EIRP as below:

5470 ~ 5725MHz Beam-Forming Mode Directional Gain = $10*\log[(10^{7.00/20} + 10^{7.00/202}/2] = 10.01$ dBi

Wi-Fi 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	34.94	24	0.4309	1
802.11a/n-HT20/ n-H40/ac-VHT20 ac-VHT40/ac-VHT80	5150 ~ 5250 5250 ~ 5350 5470 ~ 5725 5745 ~ 5850	35.78	24	0.5228	1

Note: Directional Gain Calculation of Maximum EIRP as below:

2412 ~ 2462MHz CDD Mode Directional Gain = 8.5 dBi

5745 ~ 5850MHz Beam-Forming Mode Directional Gain = $10*\log[(10^{9.0/20} + 10^{8.8/202}/2] = 11.91$ dBi

Product	AC220m Wi-Fi module OD US
Test Item	RF Exposure Evaluation (For Occupational)

Wi-Fi 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)
802.11a/n-HT20/ n-H40/ac-VHT20 ac-VHT40/ac-VHT80	5250 ~ 5350 5470 ~ 5725	29.82	20	0.1909	5

Note: Directional Gain Calculation of Maximum EIRP as below:

5470 ~ 5725MHz Beam-Forming Mode Directional Gain = $10*\log[(10^{7.00/20} + 10^{7.00/202}/2] = 10.01$ dBi

Wi-Fi 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	34.94	20	0.6205	5
802.11a/n-HT20/ n-H40/ac-VHT20 ac-VHT40/ac-VHT80	5150 ~ 5250 5250 ~ 5350 5470 ~ 5725 5745 ~ 5850	35.78	20	0.7529	5

Note: Directional Gain Calculation of Maximum EIRP as below:

2412 ~ 2462MHz CDD Mode Directional Gain = 8.5 dBi

5745 ~ 5850MHz Beam-Forming Mode Directional Gain = $10*\log[(10^{9.0/20} + 10^{8.8/202}/2] = 11.91$ 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
Wi-Fi Omni Antenna					
General Population	5GHz	0.1325	0.1325	1	Pass
Occupational	5GHz	0.1909	0.1909	5	Pass
Wi-Fi Directional Antenna					
General Population	2.4G + 5GHz	0.4309 + 0.5228	0.9537	1	Pass
Occupational	2.4G + 5GHz	0.6205 + 0.7529	1.3734	5	Pass

Per FCC 15.407 showed that All equipment shall be considered to operate in a “general population/uncontrolled” environment. Ensure that the device is installed so that the general population/uncontrolled MPE distances are observed in all cases. The calculations shown in this report were made in accordance the procedures specified in the applied test specifications

Configuration	Required Compliance Boundary (cm)	
	General Population	Occupational
2.4GHz + 5GHz	24	20

The End