

RF Exposure Evaluation Report

APPLICANT : Nokia Shanghai Bell Co. Ltd.
EQUIPMENT : Nokia FastMile 5G Gateway 3.2
BRAND NAME : Nokia
MODEL NAME : 5G16-12W-A
FCC ID : 2ADZR5G1612WA
STANDARD : 47 CFR Part 2.1091
FCC KDB 447498 D01 v06

We, Sporton International Inc. (Kunshan), would like to declare that the device has been evaluated in accordance with 47 CFR Part 2.1091 and FCC KDB 447498 D01 v06, and pass the limit. Without written approval of Sporton International Inc. (Kunshan), the test report shall not be reproduced except in full.

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Reviewed by: Tony Zhang / Supervisor

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Approved by: Kat Yin / Manager



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Revision History

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FA1O2908	Rev. 01	Initial issue of report.	Jan. 20, 2022



1. Administration Data

1.1. Testing Laboratory

Sporton International Inc. (Kunshan) is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.02.

Testing Laboratory			
Test Firm	Sporton International Inc. (Kunshan)		
Test Site Location	No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China TEL : +86-512-57900158 FAX : +86-512-57900958		
Test Site No.	Sporton Site No.	FCC Designation No.	FCC Test Firm Registration No.
	SAR01-KS	CN1257	314309

Applicant	
Company Name	Nokia Shanghai Bell Co. Ltd.
Address	No. 388, Ningqiao Rd. Pilot Free Trade Zone, Shanghai 201206 , China

Manufacturer	
Company Name	Nokia Solutions and Networks Oy
Address	Karakaari 7 02610 Espoo Finland



2. Description of Equipment Under Test (EUT)

Product Feature & Specification	
EUT Type	Nokia FastMile 5G Gateway 3.2
Brand Name	Nokia
Model Name	5G16-12W-A
FCC ID	2ADZR5G1612WA
Wireless Technology and Frequency Range	LTE Band 2 : 1850 MHz ~ 1910 MHz LTE Band 4 : 1710 MHz ~ 1755 MHz LTE Band 5 : 824 MHz ~ 849 MHz LTE Band 7: 2500 MHz ~ 2570 MHz LTE Band 12 : 699 MHz ~ 716 MHz LTE Band 13 : 777 MHz ~ 787 MHz LTE Band 25 : 1850 MHz ~ 1915 MHz LTE Band 26 : 814 MHz ~ 849 MHz LTE Band 38: 2570 MHz ~ 2620 MHz LTE Band 41: 2496 MHz ~ 2690 MHz LTE Band 42: 3450 MHz ~ 3550 MHz, 3550 MHz ~ 3600 MHz LTE Band 43: 3600 MHz ~ 3700MHz LTE Band 48: 3550 MHz ~ 3700 MHz LTE Band 66 : 1710 MHz ~ 1755 MHz LTE Band 71: 663 MHz ~ 698 MHz 5G NR n2 : 1850 MHz ~ 1910 MHz 5G NR n5 : 824 MHz ~ 849 MHz 5G NR n7 : 2500 MHz ~ 2570 MHz 5G NR n12 : 699 MHz ~ 716 MHz 5G NR n25 : 1850 MHz ~ 1915 MHz 5G NR n38 : 2570 MHz ~ 2620 MHz 5G NR n41 : 2496 MHz ~ 2690 MHz 5G NR n66 : 1710 MHz ~ 1755 MHz 5G NR n71 : 663 MHz ~ 698 MHz 5G NR n77: 3450 MHz ~ 3550 MHz, 3700 MHz ~ 3980 MHz 5G NR n78: 3450 MHz ~ 3550 MHz, 3700 MHz ~ 3800 MHz WLAN 2.4GHz Band: 2412 MHz ~ 2462 MHz WLAN 5.2GHz Band: 5180 MHz ~ 5240 MHz WLAN 5.3GHz Band: 5260 MHz ~ 5320 MHz WLAN 5.5GHz Band: 5500 MHz ~ 5720 MHz WLAN 5.8GHz Band: 5745 MHz ~ 5825 MHz
Mode	LTE: QPSK, 16QAM, 64QAM, 256QAM 5G NR : CP-OFDM / DFT-s-OFDM, PI/2 BPSK, QPSK, 16QAM, 64QAM, 256QAM WLAN 2.4GHz 802.11b/g/n HT20/HT40 WLAN 2.4GHz 802.11ax HE20/HE40 WLAN 5GHz 802.11a/n HT20/HT40 WLAN 5GHz 802.11ac VHT20/VHT40/VHT80 WLAN 5GHz 802.11ax HE20/HE40/HE80
Antenna Gain	<For LTE/5G NR> LTE Band 2 : 2.00 dBi LTE Band 4 : 2.70 dBi LTE Band 5 : 0.90 dBi LTE Band 7 : 4.60 dBi LTE Band 12 : 2.24 dBi LTE Band 13 : 1.56 dBi LTE Band 25 : 2.00 dBi LTE Band 26 : 0.90 dBi LTE Band 38 : 4.70 dBi LTE Band 41 : 4.70 dBi LTE Band 42 : 6.00 dBi LTE Band 43 : 6.10 dBi LTE Band 48 : 6.00 dBi LTE Band 66: 2.70 dBi LTE Band 71 : 2.24 dBi

	5G NR n2 : 2.00 dBi 5G NR n5 : 0.90 dBi 5G NR n7 : 4.70 dBi 5G NR n12 : 2.24 dBi 5G NR n25 : 2.00 dBi 5G NR n38 : 4.70 dBi 5G NR n41 : 4.70 dBi 5G NR n66 : 2.70 dBi 5G NR n71 : 2.24 dBi 5G NR n77 : 6.00 dBi 5G NR n78 : 6.00 dBi
HW Version	3TG01797A
SW Version	5GGW3-OMNI-1_D210400Bh3T0301E0156
EUT Stage	Identical Prototype

Remark:

1. The above EUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.
2. For DFT-s-OFDM and CP-OFDM output power measurement reduction, according to maximum power reduction for the CP-OFDM mode will not higher than DFT-s-OFDM mode, therefore, CP-OFDM measurement is unnecessary. We always chose higher power (DFT-s-OFDM mode) to perform MPE analysis.
3. 5GNR n2/n5/n7/n12/n25/n38/n41/n66/n71/n77/n78 supports SA and NSA mode.
4. 5GNR EN-DC mode, summed standalone MPE at total power level to show compliance.
5. This device support beamforming for WLAN 2.4GHz 802.11 n/ax HT20/HT40/HE20/HE40 and WLAN 5GHz 802.11 n/ac/ax HT20/HT40/VHT20/VHT40/VHT80/HE20/HE40/HE80.
6. WLAN2.4GHz/WLAN5GHz all support SISO and MIMO mode, we chose MIMO tune up power to perform MPE calculation conservatively.
7. For WLAN CDD&Beamforming mode, the MPE calculation performed separately.
8. This device supports HPUE for LTE band 41 and 5G NR n41/n77/n78 with class 2 power level, so HPUE has been performed standalone power density calculation..
9. 5GNR n38/n41/n77/n78 supports MIMO mode, MIMO MPE using single each antenna MPE summed together as MIMO MPE is more conservatively.
10. NSA and SA mode should perform MPE analysis. For the maximum power of NSA mode is the same as SA total power level, so SA standalone total power level MPE can represent NSA mode MPE.

Comments and Explanations:

1. The declared of product specification for EUT presented in the report are provided by the manufacturer, and the manufacturer takes all the responsibilities for the accuracy of product specification.
2. The maximum RF output tune up power, antenna gain also the safe distance used for evaluate RF exposure were declared by manufacturer.

For WLAN Antenna Gain

Radio	Band	Frequency (TX,MHz)	Sub Frequency	TX Antenna gain (dBi)					
				ANT1	ANT2	ANT3	ANT4	Max Gain	Beamforming Gain
WIFI 2.4G	NA	2400 ~ 2483.5	2412	3.10	2.37	2.34	3.20	3.20	6.39
			2442	3.19	2.73	2.45	2.10	3.19	6.47
			2472	3.42	3.18	2.92	1.71	3.42	6.49
WIFI 5G	U-NII-1	5150 ~ 5250	5180	4.57	3.08	3.63	2.28	4.57	6.50
			5240	3.94	2.70	3.58	1.52	3.94	6.50
	U-NII-2A	5250 ~ 5350	5260	3.94	2.70	3.58	1.52	3.94	6.50
			5300	4.77	3.14	4.10	1.14	4.77	6.38
			5320	3.68	2.56	3.95	-0.13	3.95	6.17
	U-NII-2C	5470 ~ 5725	5500	3.73	2.80	4.79	-0.12	4.79	6.08
			5540	3.49	2.50	4.50	-0.30	4.50	5.87
			5600	3.96	3.09	4.45	0.44	4.45	6.16
			5660	4.73	3.13	5.09	3.02	5.09	6.41
			5720	3.96	2.35	4.47	2.42	4.47	6.42
	U-NII-3	5725 ~ 5850	5745	4.63	2.54	4.08	2.32	4.63	6.40
			5805	3.64	3.21	3.83	3.10	3.83	6.31
			5825	3.10	2.82	3.12	2.60	3.12	6.28

For Antenna Type

Radio	Band	Antenna Type
LTE	B2/4/5/7/12/13/25/26/38/41/66/71	monopole
	B42/43/48	dipole
5G NR	n2/n5/n12/n25/n66/n71	monopole
	n7/n38/n41/n48/n77/n78	dipole
WIFI	2.4G/5G	dipole

**3. Maximum RF average output tune up power among production units****<LTE>**

Mode		Maximum Average power(dBm)
LTE	Band 2	24.00
	Band 4	24.00
	Band 5	24.00
	Band 7	24.00
	Band 12	24.00
	Band 13	24.00
	Band 25	24.00
	Band 26	24.00
	Band 38	24.00
	Band 41-HPUE	27.00
	Band 42 (3450 MHz ~3550 MHz)	24.00
	Band 42 (3550 MHz ~ 3600 MHz)	17.00
	Band 43	17.00
	Band 48	17.00
	Band 66	24.00
	Band 71	24.00

Note: LTE band 42, Chose higher tune up power to do MPE analysis only.

<5GNR>

Mode		Maximum Average power(dBm)
5GNR	n2	24.00
	n5	24.00
	n7	24.00
	n12	24.00
	n25	24.00
	n38	24.00
	n41-HPUE	27.00
	n66	24.00
	n71	24.00
	n77-HPUE	27.00
	n78-HPUE	27.00

**<For CDD/MIMO Mode>****<2.4GHz WLAN >**

Mode		Maximum Average Power (dBm)
		ANT1+2+3+4
2.4GHz	802.11b	30.00
	802.11g	30.00
	802.11n-HT20	29.61
	802.11n-HT40	29.61
	802.11ax-HE20	29.61
	802.11ax-HE40	29.61

<5GHz WLAN >

Mode		Maximum Average Power (dBm)
		ANT1+2+3+4
5.2GHz	802.11a	30.00
	802.11n-HT20	29.50
	802.11n-HT40	29.50
	802.11ac-VHT20	29.50
	802.11ac-VHT40	29.50
	802.11ac-VHT80	29.50
	802.11ax-HE20	29.50
	802.11ax-HE40	29.50
	802.11ax-HE80	29.50
5.3GHz	802.11a	23.98
	802.11n-HT20	23.81
	802.11n-HT40	23.60
	802.11ac-VHT20	23.81
	802.11ac-VHT40	23.60
	802.11ac-VHT80	23.48
	802.11ax-HE20	23.81
	802.11ax-HE40	23.60
	802.11ax-HE80	23.48
5.5GHz	802.11a	23.98
	802.11n-HT20	23.90
	802.11n-HT40	23.98
	802.11ac-VHT20	23.90
	802.11ac-VHT40	23.98
	802.11ac-VHT80	23.82
	802.11ax-HE20	23.90
	802.11ax-HE40	23.98
	802.11ax-HE80	23.82
5.8GHz	802.11a	30.00
	802.11n-HT20	29.72
	802.11n-HT40	29.60
	802.11ac-VHT20	29.72
	802.11ac-VHT40	29.60
	802.11ac-VHT80	29.60
	802.11ax-HE20	29.72
	802.11ax-HE40	29.60
	802.11ax-HE80	29.60

Note: WLAN 2.4GHz/WLAN 5GHz all support SISO/MIMO mode, we only chose MIMO tune up power to perform MPE calculation conservatively for MIMO power is higher.

<For Beamforming Mode>
<2.4GHz WLAN >

Mode		Maximum Average Power (dBm)
		ANT1+2+3+4
2.4GHz	802.11n-HT20	29.61
	802.11n-HT40	29.61
	802.11ax-HE20	29.61
	802.11ax-HE40	29.61

<5GHz WLAN >

Mode		Maximum Average Power (dBm)
		ANT1+2+3+4
5.2GHz	802.11n-HT20	29.39
	802.11n-HT40	29.39
	802.11ac-VHT20	29.39
	802.11ac-VHT40	29.39
	802.11ac-VHT80	29.39
	802.11ax-HE20	29.39
	802.11ax-HE40	29.39
	802.11ax-HE80	29.39
5.3GHz	802.11n-HT20	23.52
	802.11n-HT40	23.52
	802.11ac-VHT20	23.52
	802.11ac-VHT40	23.52
	802.11ac-VHT80	23.48
	802.11ax-HE20	23.52
	802.11ax-HE40	23.52
	802.11ax-HE80	23.48
5.5GHz	802.11n-HT20	23.52
	802.11n-HT40	23.52
	802.11ac-VHT20	23.52
	802.11ac-VHT40	23.52
	802.11ac-VHT80	23.52
	802.11ax-HE20	23.52
	802.11ax-HE40	23.52
	802.11ax-HE80	23.52
5.8GHz	802.11n-HT20	29.56
	802.11n-HT40	29.56
	802.11ac-VHT20	29.56
	802.11ac-VHT40	29.56
	802.11ac-VHT80	29.56
	802.11ax-HE20	29.56
	802.11ax-HE40	29.56
	802.11ax-HE80	29.56

Note: This device support beamforming for WLAN 2.4GHz 802.11n/ax HT20/HT40/HE20/HE40 and WLAN 5GHz 802.11n/ac/ax HT20/HT40/VHT20/VHT40/VHT80/HE20/HE40/HE80.



4. RF Exposure Limit Introduction

According to ANSI/IEEE C95.1-1992, the criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio frequency (RF) radiation as specified in §1.1310.

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
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				
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

The MPE was calculated at 29cm to show compliance with the power density limit.

The following formula was used to calculate the Power Density:

$$S = \frac{PG}{4\pi R^2}$$

Where:

S = Power Density

P = Output Power at Antenna Terminals

G = Gain of Transmit Antenna (linear gain)

R = Distance from Transmitting Antenna



5. Radio Frequency Radiation Exposure Evaluation

5.1. Standalone Power Density Calculation

Band	Frequency (MHz)	Antenna Gain (dBi)	Maximum Power (dBm)	Maximum EIRP (dBm)	Average EIRP (mW)	Power Density at 29cm (mW/cm ²)	Limit (mW/cm ²)	Power Density / Limit
LTE Band 2	1850.0	2.00	24.00	26.00	398.107	0.038	1.000	0.038
LTE Band 4	1710.0	2.70	24.00	26.70	467.735	0.044	1.000	0.044
LTE Band 5	824.0	0.90	24.00	24.90	309.030	0.029	0.549	0.053
LTE Band 7	2500.0	4.60	24.00	28.60	724.436	0.069	1.000	0.069
LTE Band 12	699.0	2.24	24.00	26.24	420.727	0.040	0.466	0.085
LTE Band 13	777.0	1.56	24.00	25.56	359.749	0.034	0.518	0.066
LTE Band 25	1850.0	2.00	24.00	26.00	398.107	0.038	1.000	0.038
LTE Band 26	814.0	0.90	24.00	24.90	309.030	0.029	0.543	0.054
LTE Band 38	2570.0	4.70	24.00	28.70	741.310	0.070	1.000	0.070
LTE Band 41	2496.0	4.70	27.00	31.70	1479.108	0.140	1.000	0.140
LTE Band 41-ENDC	2496.0	4.70	24.00	28.700	741.310	0.070	1.000	0.070
LTE Band 42	3450.0	6.00	24.00	30.00	1000.000	0.095	1.000	0.095
LTE Band 43	3600.0	6.00	17.00	23.000	199.526	0.019	1.000	0.019
LTE Band 48	3550.0	6.00	17.00	23.000	199.526	0.019	1.000	0.019
LTE Band 66	1710.0	2.70	24.00	26.70	467.735	0.044	1.000	0.044
LTE Band 71	663.0	2.24	24.00	26.24	420.727	0.040	0.442	0.090
5G NR n2	1850.0	2.00	24.00	26.00	398.107	0.038	1.000	0.038
5G NR n5	824.00	0.90	24.00	24.90	309.030	0.029	0.549	0.053
5G NR n7	2500.00	4.70	24.00	28.70	741.310	0.070	1.000	0.070
5G NR n12	699.00	2.24	24.00	26.24	420.727	0.040	0.466	0.085
5G NR n25	1850.00	2.00	24.00	26.00	398.107	0.038	1.000	0.038
5G NR n38	2570.00	4.70	24.00	28.70	741.310	0.070	1.000	0.070
5G NR n41	2496.00	4.70	27.00	31.700	1479.108	0.140	1.000	0.140
5G NR n41-ENDC	2496.00	4.70	24.00	28.700	741.310	0.070	1.000	0.070
5G NR n66	1710.00	2.70	24.00	26.70	467.735	0.044	1.000	0.044
5G NR n71	663.00	2.24	24.00	26.24	420.727	0.040	0.442	0.090
5G NR n77	3450.00	6.00	27.00	33.00	1995.262	0.189	1.000	0.189
5G NR n77_ENDC	3450.00	6.00	24.00	30.000	1000.000	0.095	1.000	0.095

Note: For 5GNR_ENDC mode is also used as single chain mode for MIMO mode.

<For CDD/MIMO Mode>

Band	Frequency (MHz)	Antenna Gain (dBi)	Maximum Power (dBm)	Maximum EIRP (dBm)	Average EIRP (mW)	Power Density at 29cm (mW/cm ²)	Limit (mW/cm ²)	Power Density / Limit
2.4GHz WLAN	2412.0	3.42	30.00	33.420	2197.860	0.208	1.000	0.208
5.2GHz WLAN	5180.0	4.57	30.00	34.570	2864.178	0.271	1.000	0.271
5.3GHz WLAN	5260.0	4.77	23.98	28.750	749.894	0.071	1.000	0.071
5.5GHz WLAN	5500.0	5.09	23.98	29.070	807.235	0.076	1.000	0.076
5.8GHz WLAN	5745.0	4.63	30.00	34.630	2904.023	0.275	1.000	0.275

**<For Beamforming mode>**

Band	Frequency (MHz)	Antenna Gain (dBi)	Maximum Power (dBm)	Maximum EIRP (dBm)	Average EIRP (mW)	Power Density at 29cm (mW/cm ²)	Limit (mW/cm ²)	Power Density / Limit
2.4GHz WLAN	2412.0	6.39	29.61	36.000	3981.072	0.377	1.000	0.377
5.2GHz WLAN	5180.0	6.50	29.39	35.890	3881.504	0.367	1.000	0.367
5.3GHz WLAN	5260.0	6.38	23.52	29.900	977.237	0.093	1.000	0.093
5.5GHz WLAN	5500.0	6.41	23.52	29.930	984.011	0.093	1.000	0.093
5.8GHz WLAN	5745.0	6.40	29.56	35.960	3944.573	0.373	1.000	0.373

Note:

1. For conservativeness, the lowest frequency of each band is used to determine the MPE limit of that band.
2. Chose the maximum power to do MPE analysis.
3. This device supports HPUE for LTE band 41 with class 2 power level, so HPUE has been performed standalone power density calculation.
4. 5G NR n78 covered by 5G NR n77 with the same power level, so only chose 5G NR n77 to perform standalone power density calculation.
5. 5GNR n38/n41/n77/n78 supports MIMO mode, MIMO MPE using single each antenna MPE summed together as MIMO MPE is more conservatively.
6. NSA and SA mode should perform MPE analysis. For the maximum power of NSA mode is the same as SA total power level, so SA standalone total power level MPE can represent NSA mode MPE.

5.2. Collocated Power Density Calculation

Maximum LTE Power Density / Limit	Maximum WLAN2.4GHz Power Density / Limit	Maximum WLAN5GHz Power Density / Limit	Σ (Power Density / Limit) of LTE + WLAN 2.4GHz + WLAN 5GHz
0.140	0.377	0.373	0.890
Maximum 5G NR Power Density / Limit	Maximum WLAN2.4GHz Power Density / Limit	Maximum WLAN5GHz Power Density / Limit	Σ (Power Density / Limit) of 5G NR + WLAN 2.4GHz + WLAN 5GHz
0.189	0.377	0.373	0.939

Maximum LTE Power Density / Limit	Maximum 5G NR Power Density / Limit	Maximum WLAN2.4GHz Power Density / Limit	Maximum WLAN5GHz Power Density / Limit	Σ (Power Density / Limit) of LTE + 5G NR + WLAN 2.4GHz + WLAN 5GHz
0.095	0.095	0.377	0.373	0.940

Maximum 5G NR Power Density / Limit	Maximum 5G NR Power Density / Limit	Maximum WLAN2.4GHz Power Density / Limit	Maximum WLAN5GHz Power Density / Limit	Σ (Power Density / Limit) of 5G NR MIMO + WLAN 2.4GHz + WLAN 5GHz
0.095	0.095	0.377	0.373	0.940

Note:

- For collocation analysis, LTE Band41-HPUE is chosen for summation due to the highest (power density/limit) among all WWAN wireless modes.
- For collocation analysis, 5GNR n77 is chosen for summation due to the highest (power density/limit) among all 5GNR modes.
- Chose the worst power density among WLAN2.4/5GHz to do co-located.
- For 5GNR EN-DC mode, always chose the highest LTE power density and the highest 5GNR power density to sum as EN-DC conservatively.
- Σ (Power Density / Limit): This is a summation of [(power density for each transmitter/antenna included in the simultaneous transmission)/ (corresponding MPE limit)], for LTE/5G NR + WLAN 2.4GHz + WLAN 5GHz, LTE + 5G NR + WLAN 2.4GHz + WLAN 5GHz and 5G NR MIMO + WLAN 2.4GHz + WLAN 5GHz.
- Considering the WWAN and 5GNR module collocation with the WLAN transmitter of the EIRP performance listed in the table above, the aggregated (power density /limit) is smaller than 1, and MPE of 4 collocated transmitters is compliant.

Conclusion:

According to 47 CFR §2.1091, the RF exposure analysis concludes that the RF Exposure is FCC compliant.

-----THE END-----