

TEST REPORT

of

FCC CFR 47 part1, 1.1307(b), 1.1310

FCC ID: 2AV76-NMOK-301W

Equipment Under Test : WIRELESS POWER CHARGING SYSTEM
Model Name : NMOK-301W
Variant Model Name(s) : -
Applicant : NIDEC MOBILITY KOREA CORPORATION
Manufacturer : NIDEC MOBILITY KOREA CORPORATION
Date of Receipt : 2022.03.23
Date of Test(s) : 2022.05.12 ~ 2023.06.27
Date of Issue : 2023.06.27

In the configuration tested, the EUT complied with the standards specified above. This test report does not assure KOLAS accreditation.

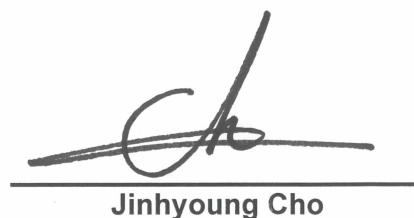
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- 2) The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received.
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We are responsible for all the information of this test report except for the data(※) provided by the customer.

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Report Number: F690501-RF-RTL003403-6

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1. General Information

1.1. Testing Laboratory

SGS Korea Co., Ltd. (Gunpo Laboratory)

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- Designation number: KR0150

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1.2. Details of Applicant

Applicant : NIDEC MOBILITY KOREA CORPORATION

Address : 790-12, Bogaewonsam-ro, Bogae-myeon, Anseong-si, Gyeonggi-do, South Korea, 17507

Contact Person : Nam, Sang-il

Phone No. : +82 2 850 5789

1.3. Details of Manufacturer

Company : Same as applicant

Address : Same as applicant

1.4. Description of EUT

Kind of Product	WIRELESS POWER CHARGING SYSTEM
Model Name	NMOK-301W
Serial Number	001
Power Supply	DC 12 V
Operation Mode	5 W, 10 W
Frequency Range	120 kHz
Antenna Type	Loop Coil Antenna
Antenna Part Number	CM00000484
H/W Version	1.0
S/W Version	1.0

1.5. Test Equipment List

Equipment	Manufacturer	Model	S/N	Cal. Date	Cal. Interval	Cal. Due
Electric and Magnetic field Probe analyzer	NARDA	EHP 200AC	170WX91017	Dec. 19, 2022	Annual	Dec. 19, 2023
Anechoic Chamber	SY Corporation	L × W × H (9.6 m × 6.4 m × 6.6 m)	N/A	N.C.R.	N/A	N.C.R.

► Support Equipment

Description	Manufacturer	Model	FCC ID
Portable Handset	Samsung Electronics Co., Ltd.	SM-G906S	A3LSMG906S
Portable Handset	Samsung Electronics Co., Ltd.	SM-G975U	A3LSMG975U
Lap top	Dell	Latitude 3510	-

Note;

- For equipment listed above that has a calibration date or calibration due date that falls within the test date range, care was taken to ensure that this equipment was used after the calibration date and before the calibration due date.

1.6. Summary of Test Results

The EUT has been tested according to the following specifications:

APPLIED STANDARD: FCC Part 1 Subpart I		
Section	Test Item(s)	Result
1.1307(b) 1.1310(e)(1)	Electronic Field, Magnetic Field	Complied

1.7. Test Report Revision

Revision	Report Number	Date of Issue	Description
0	F690501-RF-RTL003403	2022.09.02	Initial
1	F690501-RF-RTL003403-1	2022.11.28	Modified the distance of clause 2.1.
2	F690501-RF-RTL003403-2	2022.12.06	Modified the table of clause 2.5.1 and 2.5.2.
3	F690501-RF-RTL003403-3	2023.02.23	Retested the Electronic Field and Magnetic Field on side E of the EUT.
4	F690501-RF-RTL003403-4	2023.04.24	Add the estimate result for other distance and validation of estimate
5	F690501-RF-RTL003403-5	2023.05.25	Revise test report with measurement information
6	F690501-RF-RTL003403-6	2023.06.27	Added the estimated result values at 0 mm

1.8. Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

Parameter	Uncertainty
Electric Field	19.44 %
Magnetic Field	19.86 %

All measurement uncertainty values are shown with a coverage factor of $k=2$ to indicate a 95 % level of confidence.

1.9. Worst Case of Test Configurations

In order to check all kinds of possible configurations, EUT was evaluated with appropriate client and under each charging condition as below table.

Charging mode with client device	Mode		Description
Model: SM-G906S FCC ID: 649E-SMG906S Model: SM-G975U FCC ID: 649E-SMG975U	5 W	10 W	1 % of battery 50 % of battery 99 % of battery
	Ant. 1: 120 kHz	Ant. 1: 120 kHz	
	SM-G906S	SM-G975U	

Mode	Battery	Frequency (kHz)	E-field Strength (V/m)	H-field Strength (A/m)
5 W	1 %	120	<u>73.40</u>	<u>1.589</u>
	50 %		69.62	1.534
	99 %		68.29	1.446
10 W	1 %	120	<u>89.43</u>	<u>1.505</u>
	50 %		88.18	1.443
	99 %		87.78	1.428

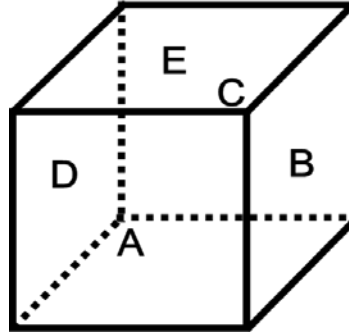
Note;

- EUT was investigated with client device under normal charging condition as above then worst value was only reported.

2. Test Result

2.1. Isotropic Probe Test Setup

The measurement probe (EHP-200AC) is a regular hexahedron and supports 3-axis isotropic probe.



A: Front of measurement probe
 B: Right of measurement probe
 C: Rear of measurement probe
 D: Left of measurement probe
 E: Top of measurement probe

*Bottom of measurement probe is not used to measure RF exposure condition owing to connection with a stick.

- At 4 cm distance, measurement isotropic probe was investigated by rotating the probe through various angles for one of the EUT's sides as below.

Measurement Point	A	B	C	D	E
Direction	Front	Right	Rear	Left	Top
Measurement Point	A to B	B to C	C to D	D to A	N/A
Direction	Front to Right	Right to Rear	Rear to Left	Left to Front	-
Measurement Point	A to E	B to E	C to E	D to E	N/A
Direction	Front to Top	Right to Top	Rear to Top	Left to Top	-

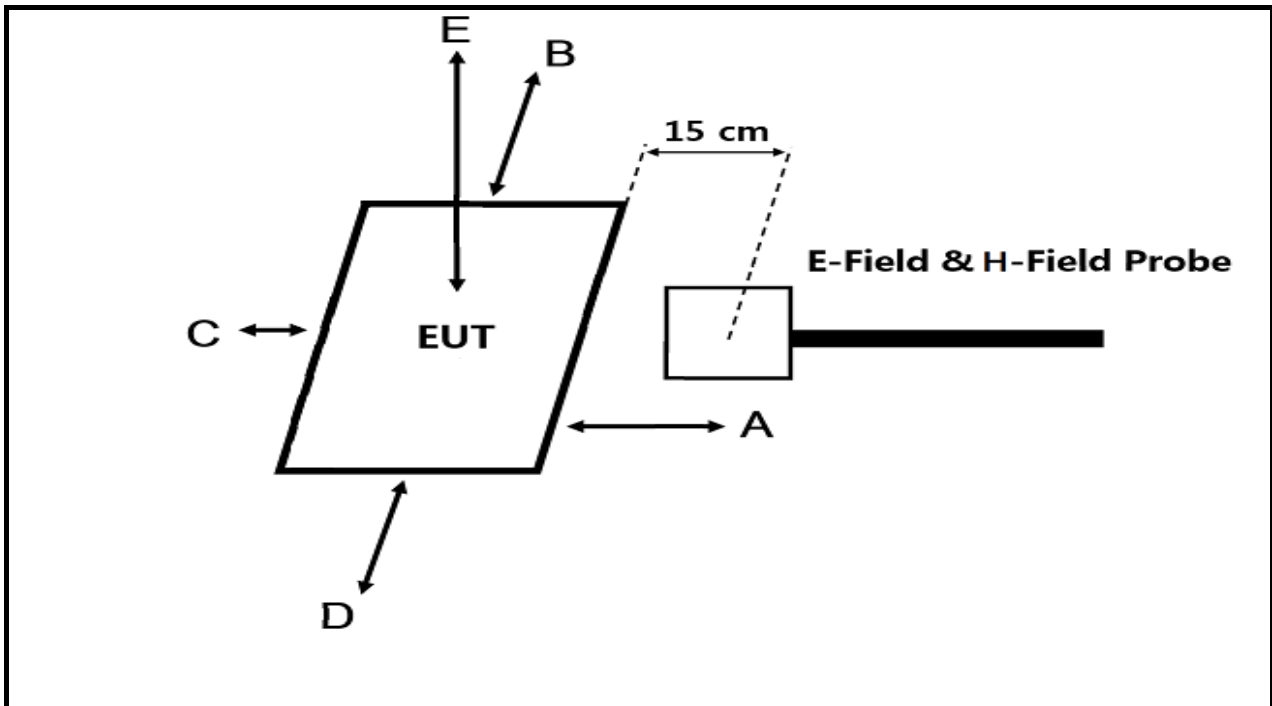
- When the worst angle among all angles was found, RF exposure measurement should be adjusted from worst angle.

- Worst Case

E-field: One of the several angles was found as **Point A** of isotropic probe.

H-field: One of the several angles was found as **Point C** of isotropic probe.

2.2. EUT Test Setup



2.3. Measurement procedure

- The RF exposure test was performed in anechoic chamber.
- The measurement probe was placed at test distance (4, 6, 8, 10, 15 cm) which is between the edge of the charger and the geometric center of probe.
- Measurement was performed on each side of the EUT as described above picture (A, B, C, D, E).
- The EUT was measured according to the dictates of KDB 680106 D01 RF Exposure Wireless Charging Apps v03.

Note;

- Because of measurement probe antenna size, minimum distance between charger and probe is 4 cm for E-Field and H-Field.
- The EUT installed to the vehicle was charged from the top, so it was measured from 5 sides except the bottom.
- According to the manufacturer's declaration, the minimum separation distance between the EUT(A, B, C and D sides) and the probe excluding the E side of the EUT was 5 cm, and thus the evaluation was carried out at 4 cm or more that.

2.4. Environmental evaluation and exposure limit according to FCC CFR 47 part 1, 1.1307(b), 1.1310.

§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), except in the case of portable devices which shall be evaluated according to the provisions of FCC part 2.1093 of this chapter.

Table 1 to § 1.1310(e)(1) - 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)
(i) Limits for Occupational /Control 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
300-1 500	-	-	f/300	<6
1 500-100 000	-	-	5	<6
(ii) Limits for General Population/Uncontrolled Exposures				
<u>0.3-1.34</u>	<u>614</u>	<u>1.63</u>	*(100)	<30
1.34-30	824/f	2.19/f	*(180/f ²)	<30
30-300	27.5	0.073	0.2	<30
300-1 500	-	-	f/1 500	<30
1 500-100 000	-	-	1.0	<30

f = frequency in MHz. * = Plane wave equivalent power density.

2.5. E and H field strength

Ambient temperature : $(23 \pm 1) ^\circ\text{C}$
Relative humidity : 47 % R.H.

2.5.1. E-Field Strength at from the edges surrounding the EUT

Test Condition: 5 W Operating mode with client device (1 % battery status of client device)

Frequency (kHz)	Distance (cm)	EUT Sides					Limits (V/m)
		A (V/m)	B (V/m)	C (V/m)	D (V/m)	E (V/m)	
120	15	2.66	3.46	1.91	6.04	8.32	614
	10	6.44	8.28	2.89	9.30	16.54	
	8	9.25	14.41	12.33	14.88	26.57	
	6	14.40	28.25	16.85	23.92	40.60	
	Contact, 4	21.70	61.24	21.41	58.34	73.40	

Test Condition: 10 W Operating mode with client device (1 % battery status of client device)

Frequency (kHz)	Distance (cm)	EUT Sides					Limits (V/m)
		A (V/m)	B (V/m)	C (V/m)	D (V/m)	E (V/m)	
120	15	4.40	4.99	2.69	4.07	8.95	614
	10	8.76	12.15	3.91	10.23	21.26	
	8	11.38	19.09	5.31	15.14	29.65	
	6	17.59	36.82	24.02	30.08	50.07	
	Contact, 4	24.68	79.89	26.41	64.99	89.43	

2.5.2. H-Field Strength at from the edges surrounding the EUT

Test Condition: 5 W Operating mode with client device (1 % battery status of client device)

Frequency (kHz)	Distance (cm)	EUT Sides					Limits (A/m)
		A (A/m)	B (A/m)	C (A/m)	D (A/m)	E (A/m)	
120	15	0.205	0.159	0.169	0.156	0.166	1.63
	10	0.623	0.327	0.321	0.276	0.251	
	8	0.981	0.372	0.580	0.405	0.344	
	6	1.082	0.541	0.846	0.445	0.427	
	Contact, 4	1.496	<u>1.589</u>	1.376	0.850	0.541	

Test Condition: 10 W Operating mode with client device (1 % battery status of client device)

Frequency (kHz)	Distance (cm)	EUT Sides					Limits (A/m)
		A (A/m)	B (A/m)	C (A/m)	D (A/m)	E (A/m)	
120	15	0.159	0.164	0.183	0.154	0.159	1.63
	10	0.233	0.276	0.340	0.272	0.270	
	8	0.324	0.458	0.491	0.454	0.352	
	6	0.676	0.623	0.980	0.696	0.500	
	Contact, 4	<u>1.505</u>	0.925	1.321	0.806	0.795	

2.6. H-Field Strength Calculation of the EUT

2.6.1. Calculation of μ_r (relative permeability)

According to the self-inductance formula, μ_r (relative permeability) can be obtained.

$$x = \sqrt{1 + \left(\frac{d}{2l}\right)^2}$$

$$L = 2l \left[\ln \left\{ \left(\frac{2l}{d} \right) (1 + x) \right\} - x + \frac{\mu_r}{4} + \frac{d}{2l} \right]$$

$$\mu_r = 4 \left[\frac{L}{2l} - \ln \left\{ \left(\frac{2l}{d} \right) (1 + x) \right\} + x - \frac{d}{2l} \right]$$

Where;

L: self inductance [nH], Qi specification of WIRELESS POWER CONSORTIUM

d: diameter of the wire [cm]

l: length of the wire in [cm]

μ_r : relative permeability

L [nH]	d [cm]	l [cm]	μ_r
11 500	0.115	153	120.01

2.6.2. Calculation of theoretical H-field strength with Biot-Savart's law

According to Biot-Savart law, the value of the B-field at the distance z from the coil is expressed as follows.

$$B_z = \frac{\mu_0 I R^2}{2(R^2 + z^2)^{3/2}}$$

Convert the value of the B-field to the H-field.

$$B_z = \mu_0 \times H_z,$$

$$H_z = \frac{I R^2}{2(R^2 + z^2)^{3/2}}$$

Considering the number of turns and relative permeability of coil, it is expressed as follows.

$$H_z = \frac{I R^2}{2(R^2 + z^2)^{3/2}} \times \frac{N}{\mu_r}$$

Where;

I: the current to the EUT during charging can be obtained from the power supply equipment [A]

R: the radial of EUT' coil antenna [m]

z: the distance from the coil antenna to the point to be measured [m]

N: the number of turns in the coil

μ_r : relative permeability

Test Condition	I [A]	R [m]	μ_r	N	z [m]	Actual measuring distance ³⁾ [m]	Theoretical H-field value [A/m]
5 W	0.700	0.027	120.01	12	0.020 ¹⁾	0.008	0.673
					0.012 ²⁾	0	0.989
10 W	1.100	0.027	120.01	12	0.020 ¹⁾	0.008	1.057
					0.012 ²⁾	0	1.554

Note;

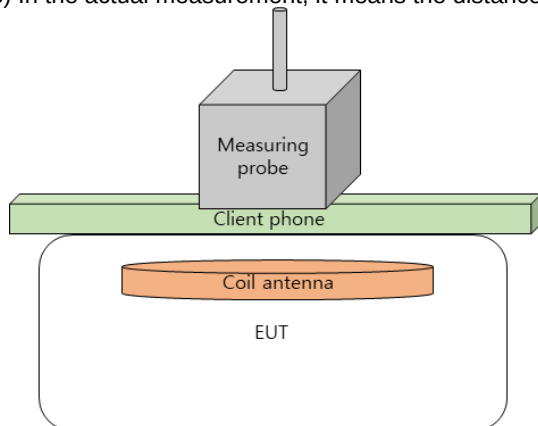
1) Distance z from the EUT's coil antenna to the measurement point is sum of all of followings.

- 4 mm, gap from EUT's coil antenna to edge of the EUT
- 8 mm, client phone thickness
- 8 mm, gap from edge of measuring probe to sensing elements of measuring probe

2) Distance z is from the EUT's coil antenna to the measurement point and includes all of the following.

- 4 mm, gap from EUT's coil antenna to edge of the EUT
- 8 mm, client phone thickness

3) In the actual measurement, it means the distance between the EUT and the sensing elements of the probe.



8 mm, the gap from edge of measuring probe to sensing material
8 mm, the client phone thickness
4 mm, the gap from EUT's coil antenna to edge of the EUT

2.6.3. The validation of H-field strength

Frequency (kHz)	Test Condition	Distance (cm)	Theoretical H-field value [A/m]	30 % tolerance of theoretical H-field value [A/m]		EUT Sides E (A/m)	Limits (A/m)
				Min.	Max	Measured value	
120	5 W (1 % battery status of client device)	Contact, 4 ¹⁾	0.673	0.471	0.874	0.541	1.63
	10 W (1 % battery status of client device)	Contact, 4 ¹⁾	1.057	0.740	1.374	0.795	

Note;

- 1) Probe has 4 cm radius enclosure but each sensing element is located 8mm from the probe edge.
Therefore, actual distance in measurement is 8 mm.

2.6.4. The estimation of H-field strength

Frequency (kHz)	Test Condition	Distance (cm)	EUT Sides E	Limits (A/m)
			Theoretical H-field value [A/m]	
120	5 W (1 % battery status of client device)	Contact, 0	0.989	1.63
	10 W (1 % battery status of client device)	Contact, 0	1.554	

Estimation formula and theoretical value have 30% agreement with actual measurement. Estimation for 0 mm field strength with validated formula complies limit.

- End of the Test Report -