SAR EVALUATION REPORT

Equipment under test	Flat Panel Detector
Model name	FXRD-1717NAW
Derivative model	FXRD-1717NBW
FCC ID	PFRFXRD-1717NAW
Module FCC ID	RYK-WPEA-121N
Applicant	Vieworks Co., Ltd.
Manufacturer	Vieworks Co., Ltd.
Date of test(s)	2015.03.30 ~ 2015.04.06
Date of issue	2015.04.17

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Revision history

Revision	Date of issue	Test report No.	Description
-	2015.04.17	KES-SR-15T0009	Initial

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1. General information

1.1. EUT description

Equipment under test	Flat Panel Detector
Model name	FXRD-1717NAW
Serial number	N/A
Frequency range	2 412 ㎒ ~ 2 462 ㎒: 11 channel (802.11 b/g/n_HT20) 2 422 ㎒ ~ 2 452 ㎒: 7 channel (11n_HT40) 5 745 ㎒ ~ 5 825 ㎒: 5 channel (11a/n_HT20_Non DFS) 5 755 ㎒ ~ 5 795 ㎒: 2 channel (11n_HT40_Non DFS) 5 180 ㎒ ~ 5 240 ㎒: 4 channel (11a/n_HT20_Non DFS) 5 190 ㎒ ~ 5 230 ㎒: 2 channel (11n_HT40_Non DFS)
Body worn accessory	None
Antenna type & gain	PCB antenna
Power source	24 V DC // 1 A

Notes:

1. User's must use always on the front surface when to operate this product. And the side and rear surface must not use except for front surface.
2. Duty cycle is > 98 %.

1.2. Highest SAR summary

Equipment class	Frequency band	Tissue type	Reported SAR value 1g-SAR (W/kg)
DTS	WLAN 2.4 ㎓ band	Head	0.081
		Body	0.063
	WLAN 5.8 ㎓ band	Head	0.034
		Body	0.034
UNII	WLAN 5.2 ㎓ band	Head	0.018
		Body	0.014
Simultaneous transmission SAR per KDB 690783 D01v01r03			N/A

Notes:

1. WLAN 2.4 ㎓ band and 5 ㎓ band share same antenna path and cannot transmit simultaneously.
2. This device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (1.6 W/kg) specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1992, and had been tested in accordance with the measurement methods and procedures specified in IEEE 1528-2003.

1.3. Maximum output power specifications

Band	Mode	Bandwidth (㎒)	Channel	Frequency (㎒)	Maximum output power	
					Ant. 1(dBm)	Ant. 2(dBm)
2.4 ㎓	802.11b	20	1	2 412	17.00	17.00
			6	2 437	17.00	17.00
			11	2 462	15.00	15.00
	802.11g	20	1	2 412	10.00	11.00
			6	2 437	11.00	10.00
			11	2 462	9.00	9.00
	802.11n	20	1	2 412	10.00	11.00
			6	2 437	11.00	10.00
			11	2 462	9.00	10.00
		40	3	2 422	9.00	9.00
			6	2 437	9.00	8.00
			9	2 452	8.00	8.00
5.2 ㎓	802.11a	20	36	5 180	10.00	11.00
			40	5 200	10.00	11.00
			44	5 220	11.00	11.00
			48	5 240	11.00	11.00
	802.11n	20	36	5 180	10.00	11.00
			40	5 200	10.00	11.00
			44	5 220	10.00	11.00
			48	5 240	10.00	11.00
		40	38	5 190	11.00	11.00
			46	5 230	11.00	11.00
5.8 ㎓	802.11a	20	149	5 745	11.00	13.00
			153	5 765	13.00	13.00
			157	5 785	14.00	14.00
			161	5 805	13.00	14.00
			165	5 825	13.00	14.00
	802.11n	20	149	5 745	11.00	12.00
			153	5 765	12.00	12.00
			157	5 785	13.00	13.00
			161	5 805	13.00	13.00
			165	5 825	13.00	14.00
		40	151	5 755	11.00	12.00
			159	5 795	14.00	14.00

Note:

1. The device operates using the following maximum output power specifications. The reported SAR is measured SAR value adjusted for maximum output power tolerance.
2. Tune up tolerance is ±1.0 dB.

1.4. Guidance applied

- FCC KDB Publication 865664 D01 v01r03- D02 v01r01 (SAR measurement up to 6 ㎓)
- FCC KDB Publication 447498 D01 v05r02 (General SAR guidance)
- FCC KDB Publication 248227 D01 v01r02 (SAR considerations for 802.11 devices)
- FCC KDB Publication 865664 D02 v01r01 (SAR reporting)

1.5. Test conditions

Ambient temperature	(22 ± 2) ℃
Tissue simulating liquid	(22 ± 2) ℃
Humidity	(55 ± 5) % R.H.

1.6. SAR definition

Specific Absorption Rate is defined as the time derivative (rate) of the incremental energy (dU) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given density (ρ). It is also defined as the rate of RF energy absorption per unit mass at a point in an absorbing body (see Figure 1).

$$SAR = \frac{d}{dt}\left(\frac{dU}{dm}\right) = \frac{d}{dt}\left(\frac{dU}{\rho d\upsilon}\right)$$

Figure 1. SAR Mathematical equation

SAR is expressed in units of Watts per Kilogram(W/kg)

$$SAR = \frac{\sigma E^2}{\rho}$$

Where:

σ = Conductivity of the tissue-simulating material (S/m)

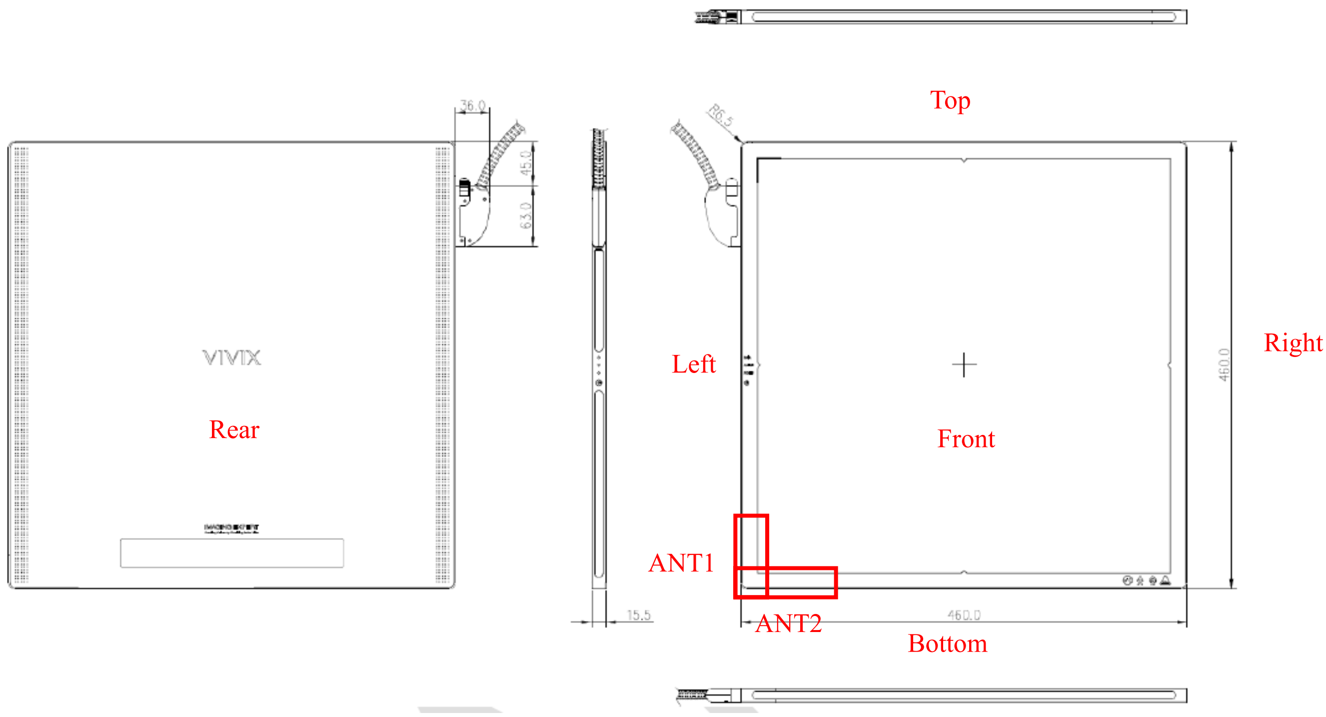
ρ = Mass density of the tissue-simulating material (kg/㎥)

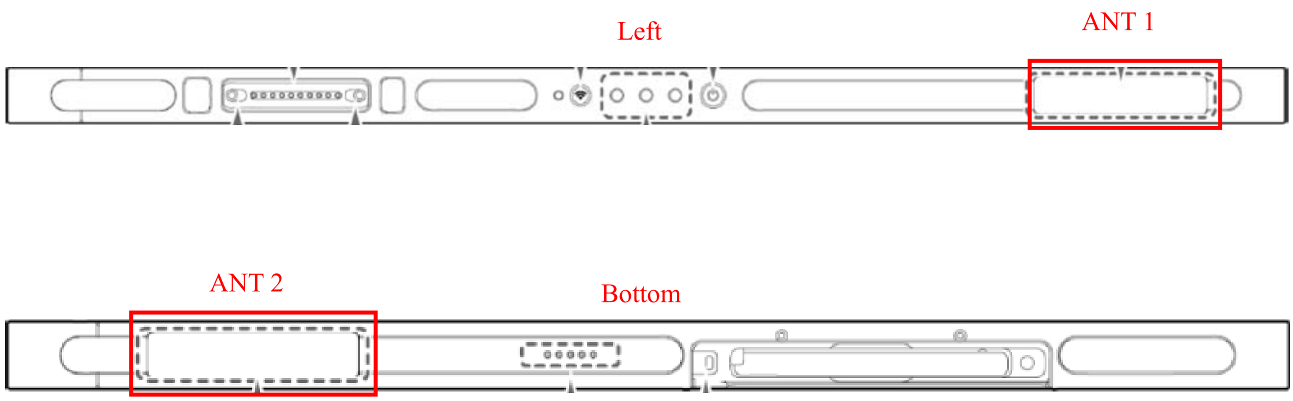
E = Total RMS electric field strength (V/m)

NOTE:

The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relations to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane.

1.7. EUT antenna location





2. SAR measurement system

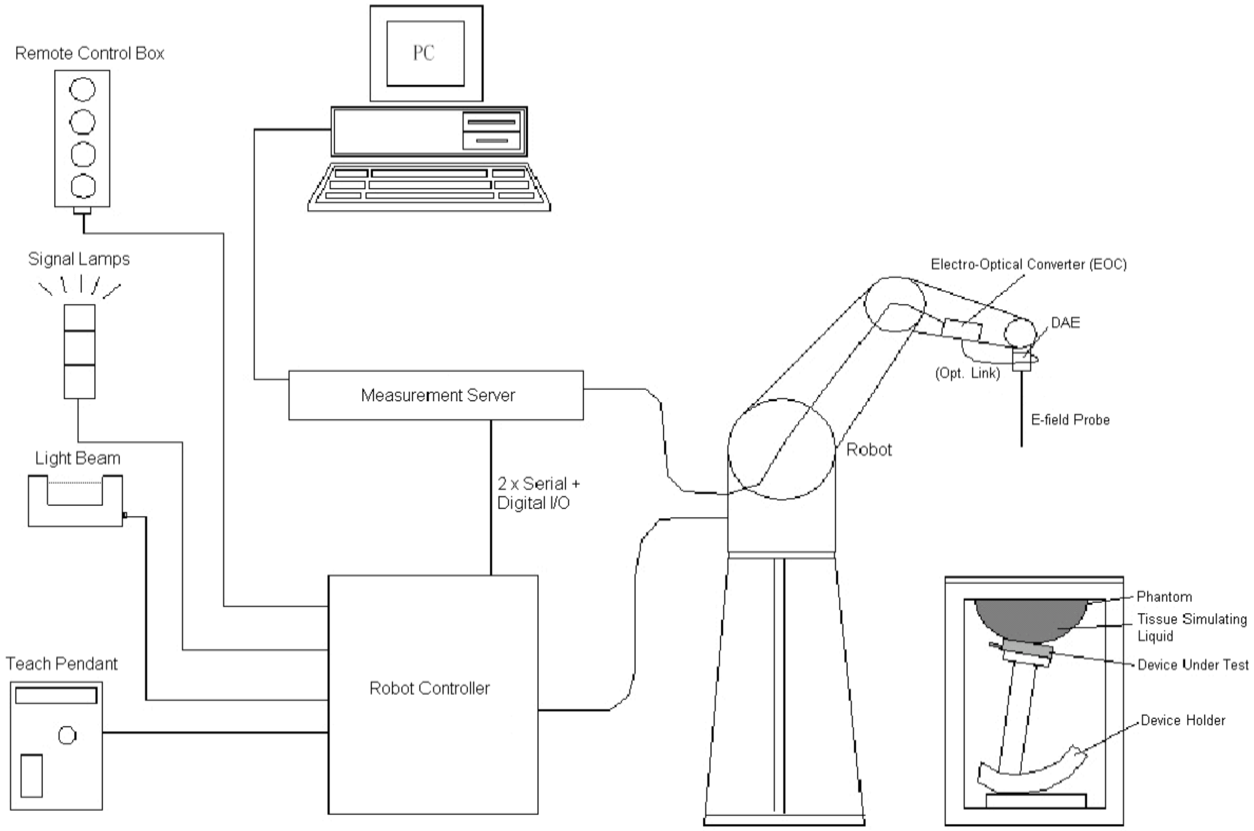


Figure 2. SPEAG DASY system configuration

The DASY system for performance compliance tests is illustrated above graphically. This system consists of the following items:

- A standard high precision 6-axis robot with controller, a teach pendant and software
- A data acquisition electronic (DAE) attached to the robot arm extension
- A dosimetric probe equipped with an optical surface detector system
- The electro-optical converter (EOC) performs the conversion between optical and electrical signals
- A measurement server performs the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the accuracy of the probe positioning
- A computer operating Windows XP
- DASY software
- Remove control with teach pendant and additional circuitry for robot safety such as warming lamps, etc.
- The SAM twin phantom and/or ELI phantom
- A device holder
- Tissue simulating liquid
- Dipole for evaluating the proper functioning of the system

2.1. Robot

The DASY system uses the high precision robots from Stäubli SA (France). For the 6-axis controller system, the robot controller version from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability ±0.035 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)

Figure 3. SPEAG DASY 4

2.2. Probe

The SAR measurement is conducted with the dosimetric probe. The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency.

Model	EX3DV4
Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Frequency	10 ㎒ to > 6 ㎓ Linearity: ± 0.2 ㏈ (30 ㎒ to 6 ㎓)
Directivity	± 0.3 dB in TSL (rotation around probe axis) ± 0.5 dB in TSL (rotation normal to probe axis)
Dynamic Range	10 µW/g to > 100 ㎽/g Linearity: ± 0.2 ㏈ (noise: typically < 1 µW/g)
Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm

Figure 4. Probe

2.3. Data Acquisition Electronics (DAE)

Model	DAE4
Construction	Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY4/5 embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop.
Measurement Range	-100 to +300 mV (16 bit resolution and two range settings: 4 mV, 40 0mV)
Input Offset Voltage	± 0.2 dB in HSL (rotation around probe axis) ± 0.3 dB in tissue material (rotation normal to probe axis)
Input Bias Current	< 50 fA
Dimensions	60 x 60 x 68 mm

Figure 5. DAE

2.4. Phantoms

Model	Twin SAM
Construction	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.
Material	Vinylester, glass fiber reinforced (VE-GF)
Shell Thickness	2 ± 0.2 mm (6 ± 0.2 mm at ear point)
Dimensions	Length: 1000 mm Width: 500 mm Height: adjustable feet
Filling Volume	approx. 25 liters

Figure 6. Twin SAM

Model	ELI
Construction	Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is compatible with all SPEAG dosimetric probes and dipoles.
Material	Vinylester, glass fiber reinforced (VE-GF)
Shell Thickness	2.0 ± 0.2 mm (bottom plate)
Dimensions	Major axis: 600 mm Minor axis: 400 mm
Filling Volume	approx. 30 liters

Figure 7. ELI

2.5. Device holder

Model	Mounting device
Construction	In combination with the Twin SAM Phantom or ELI4, the Mounting Device enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to IEC, IEEE, FCC or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).
Material	POM

Figure 8. Mounting device

Model	Laptop extensions kit
Construction	Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices according to IEC 62209-2 (e.g., laptops, cameras, etc.). It is lightweight and fits easily on the upper part of the Mounting Device in place of the phone positioner.
Material	POM, Acrylic glass, Foam

Figure 9. Laptop extensions kit

3. SAR measurement procedure

Step 1: Power reference measurement

The power reference measurement and power reference measurements are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. The minimum distance of probe sensors to surface is 2 ㎜. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

Step 2 and 3: Area scan & zoom scan procedures

The entire evaluation of the spatial peak values is performed within the post-processing engine (SEMCAD). The system always gives the maximum values for the 1 g and 10 g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

1. The extraction of the measured data (grid and values) from the zoom scan.
2. The calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
3. The generation of a high-resolution mesh within the measured volume
4. The interpolation of all measured values from the measurement grid to the high-resolution grid
5. The extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
6. The calculation of the averaged SAR within masses of 1 g and 10 g.

<table>
<tr><td colspan="3"></td><td>$\leq$ 3 GHz</td><td>> 3 GHz</td></tr>
<tr><td colspan="3">Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface</td><td>5 ± 1 mm</td><td>½·δ·ln(2) ± 0.5 mm</td></tr>
<tr><td colspan="3">Maximum probe angle from probe axis to phantom surface normal at the measurement location</td><td>30° ± 1°</td><td>20° ± 1°</td></tr>
<tr><td colspan="3" rowspan="2">Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}</td><td>$\leq$ 2 GHz: $\leq$ 15 mm
2 – 3 GHz: $\leq$ 12 mm</td><td>3 – 4 GHz: $\leq$ 12 mm
4 – 6 GHz: $\leq$ 10 mm</td></tr>
<tr><td colspan="2">When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device.</td></tr>
<tr><td colspan="3">Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}</td><td>$\leq$ 2 GHz: $\leq$ 8 mm
2 – 3 GHz: $\leq$ 5 mm[*]</td><td>3 – 4 GHz: $\leq$ 5 mm[*]
4 – 6 GHz: $\leq$ 4 mm[*]</td></tr>
<tr><td rowspan="3">Maximum zoom scan spatial resolution, normal to phantom surface</td><td colspan="2">uniform grid: $\Delta z_{Zoom}(n)$</td><td>$\leq$ 5 mm</td><td>3 – 4 GHz: $\leq$ 4 mm
4 – 5 GHz: $\leq$ 3 mm
5 – 6 GHz: $\leq$ 2 mm</td></tr>
<tr><td rowspan="2">graded grid</td><td>$\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface</td><td>$\leq$ 4 mm</td><td>3 – 4 GHz: $\leq$ 3 mm
4 – 5 GHz: $\leq$ 2.5 mm
5 – 6 GHz: $\leq$ 2 mm</td></tr>
<tr><td>$\Delta z_{Zoom}(n>1)$: between subsequent points</td><td colspan="2">$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$</td></tr>
<tr><td>Minimum zoom scan volume</td><td colspan="2">x, y, z</td><td>$\geq$ 30 mm</td><td>3 – 4 GHz: $\geq$ 28 mm
4 – 5 GHz: $\geq$ 25 mm
5 – 6 GHz: $\geq$ 22 mm</td></tr>
<tr><td colspan="5">Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.
[*] When zoom scan is required and the <u>reported</u> SAR from the area scan based 1-g SAR estimation procedures of KDB 447498 is $\leq$ 1.4 W/kg, $\leq$ 8 mm, $\leq$ 7 mm and $\leq$ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.</td></tr>
</table>

Figure 10. Area and zoom scan resolutions per FCC KDB Publication 865664 D01v01r03

Step 4: Power drift measurement

The power drift measurement measures the field at the same location as the most recent power reference measurement within the same procedure, and with the same settings. The power drift measurement gives the field difference in dB from the reading conducted within the last power reference measurement. This allows a user to monitor the power drift of the device under test within a batch process. The measurement procedure is the same as Step 1.

4. Tissue simulating liquids

For the measurement of the field distribution inside the phantom with DASY, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm, which is shown in figure 11.

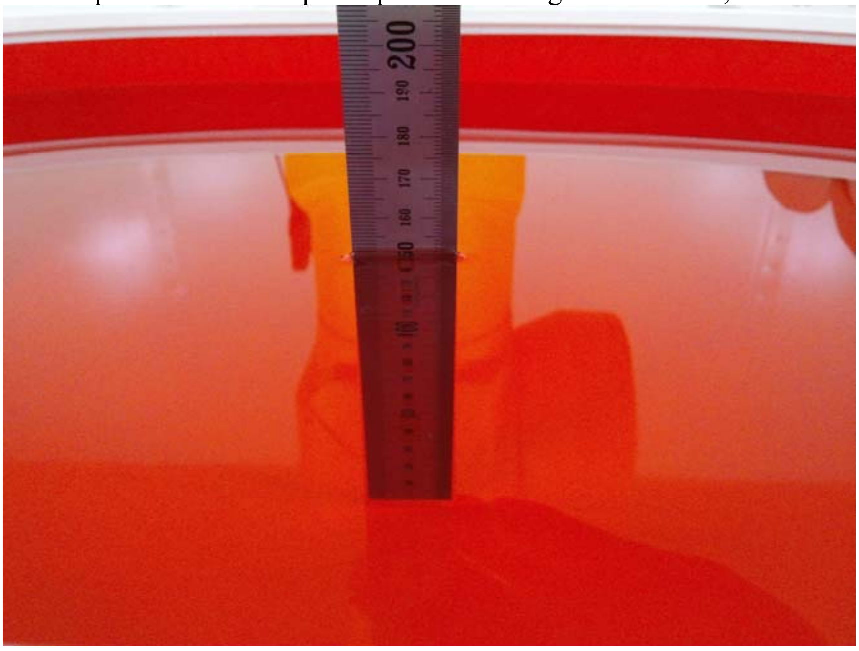


Figure 11. Liquid height photo

The dielectric parameters of the liquids were verified prior to the SAR evaluation using an agilent dielectric probe kit and an agilent network analyzer.

The following table shows the measuring results for simulating liquid.

WLAN 2.4 ㎓ band

Frequency (㎒)	Tissue type	Liquid temp.(°C)	Parameters	Target value	Measured value	Deviation (%)	Limit (%)	Data
2 450	Head	22.0	Permittivity (εr)	39.20	38.80	-1.02	±5	2015.04.06
			Conductivity (σ)	1.80	1.77	-1.67	±5	2015.04.06
2 437	Head	22.0	Permittivity (εr)	-	38.90	-0.77	±5	2015.04.06
			Conductivity (σ)	-	1.76	-2.22	±5	2015.04.06
2 450	Body	22.0	Permittivity (εr)	52.70	52.20	-0.95	±5	2015.04.06
			Conductivity (σ)	1.95	2.02	3.59	±5	2015.04.06
2 437	Body	22.0	Permittivity (εr)	-	52.20	-0.95	±5	2015.04.06
			Conductivity (σ)	-	2.02	3.59	±5	2015.04.06

WLAN 5.2 ㎓ band

Frequency (㎒)	Tissue type	Liquid temp.(°C)	Parameters	Target value	Measured value	Deviation (%)	Limit (%)	Data
5 200	Head	22.0	Permittivity (εr)	36.00	36.80	2.22	±5	2015.04.01
			Conductivity (σ)	4.66	4.52	-3.00	±5	2015.04.01
5 180	Head	22.0	Permittivity (εr)	-	36.90	2.50	±5	2015.04.01
			Conductivity (σ)	-	4.48	-3.86	±5	2015.04.01
5 240	Head	22.0	Permittivity (εr)	-	36.70	1.94	±5	2015.04.01
			Conductivity (σ)	-	4.56	-2.15	±5	2015.04.01
5 200	Body	22.0	Permittivity (εr)	49.00	47.90	-2.24	±5	2015.03.31
			Conductivity (σ)	5.30	5.23	-1.32	±5	2015.03.31
5 180	Body	22.0	Permittivity (εr)	-	48.10	-1.84	±5	2015.03.31
			Conductivity (σ)	-	5.19	-2.08	±5	2015.03.31
5 240	Body	22.0	Permittivity (εr)	-	47.60	-2.86	±5	2015.03.31
			Conductivity (σ)	-	5.35	0.94	±5	2015.03.31

WLAN 5.8 ㎓ band

Frequency (㎒)	Tissue type	Liquid temp.(°C)	Parameters	Target value	Measured value	Deviation (%)	Limit (%)	Data
5 800	Head	22.0	Permittivity (εr)	35.30	34.50	-2.27	±5	2015.04.02
			Conductivity (σ)	5.27	5.21	-1.14	±5	2015.04.02
5 745	Head	22.0	Permittivity (εr)	-	34.60	-1.98	±5	2015.04.02
			Conductivity (σ)	-	5.07	-3.80	±5	2015.04.02
5 785	Head	22.0	Permittivity (εr)	-	34.50	-2.27	±5	2015.04.02
			Conductivity (σ)	-	5.16	-2.09	±5	2015.04.02
5 825	Head	22.0	Permittivity (εr)	-	34.50	-2.27	±5	2015.04.02
			Conductivity (σ)	-	5.24	-0.57	±5	2015.04.02
5 800	Body	22.0	Permittivity (εr)	48.20	48.60	0.83	±5	2015.03.30
			Conductivity (σ)	6.00	5.95	-0.83	±5	2015.03.30
5 745	Body	22.0	Permittivity (εr)	-	48.70	1.04	±5	2015.03.30
			Conductivity (σ)	-	5.92	-1.33	±5	2015.03.30
5 785	Body	22.0	Permittivity (εr)	-	48.60	0.83	±5	2015.03.30
			Conductivity (σ)	-	5.97	-0.50	±5	2015.03.30
5 825	Body	22.0	Permittivity (εr)	-	48.60	0.83	±5	2015.03.30
			Conductivity (σ)	-	6.02	0.33	±5	2015.03.30

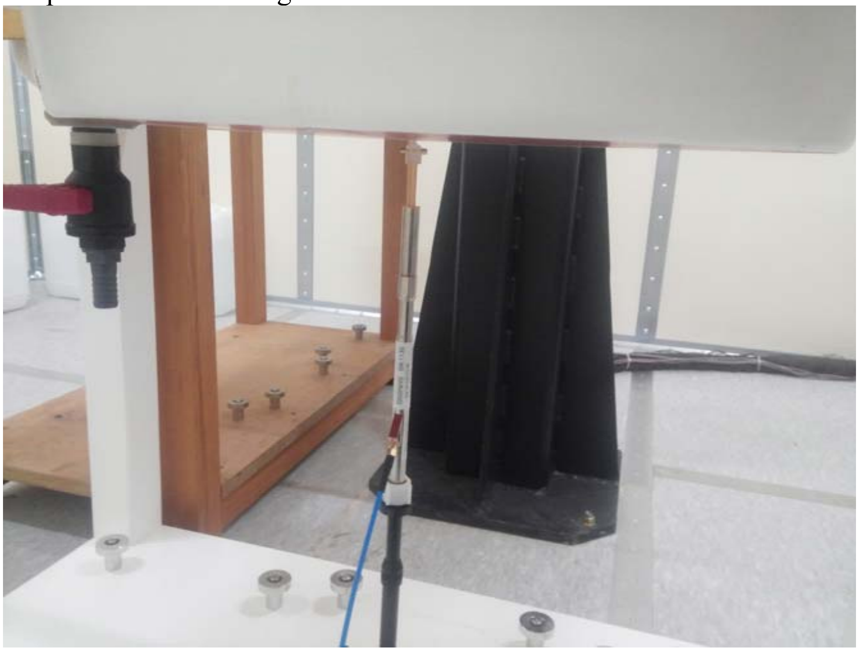
5. System verification and validation

5.1. Procedure

SAR measurement was prior to assessment, the system is verified to the ±10 % of the specifications at each frequency band by using the system verification kit.

- Cabling the system, using the verification kit equipments.
- Generate about 100 ㎽ or 250 ㎽ input level from the signal generator to the dipole antenna.
- Dipole antenna was placed below the flat phantom.
- The measured one-gram SAR at the surface of the phantom above the dipole feed-point should be within 10 % of the target reference value.
- The results are normalized to 1 W input power.

Note;
SAR verification was performed according to the FCC KDB 865664 D01v01r03.



5.2. System verification

Frequency (㎒)	Tissue type	Probe (S/N)	Antenna (S/N)	1 W Target SAR_{1g} (W/kg)	Measured SAR_{1g} (W/kg)	1 W Normalized SAR_{1g} (W/kg)	Deviation (%)	Limit (%)	Data
2 450	Head	3879	896	52.6	13.2	52.8	0.38	±10	2015.04.06
	Body	3879	896	50.6	11.9	47.6	-5.93	±10	2015.04.06
5 200	Head	3879	1130	79.4	7.57	75.7	-4.66	±10	2015.04.01
	Body	3879	1130	76.1	8.17	81.7	7.36	±10	2015.03.31
5 800	Head	3879	1130	81.0	8.31	83.1	2.59	±10	2015.04.02
	Body	3879	1130	77.6	8.46	84.6	9.02	±10	2015.03.30

5.3. System validation

Per FCC KDB 865664 D02v01r01, SAR system validation status should be documented to confirm measurement accuracy. The SAR systems (including SAR probes, system components and software versions) used for this device were validated against its performance specifications prior to the SAR measurements. Reference dipoles were used with the require tissue-equivalent media for system validation, according to the procedures outlined in IEEE 1528-2003 and FCC KDB 865664 D01v01r03. Since frequency within the valid frequency range of the probe calibration point, using the system that normally operates with the probe for routine SAR measurements and according to the required tissue-equivalent media. A tabulated summary of the system validation status including the validation date(s), measurement frequencies, SAR probe and tissue dielectric parameters has been included.

f (MHz)	Date	Probe S/N	Probe cal. point	Tissue type	Dielectric parameters		CW validation			Modulated Validation		
					Permittivity	Conductivity	Sensitivity	Probe Linearity	Probe Isotropy	Mod. Type	Duty Factor	PAR
2 450	2015.01.21	3879	2 450	Head	38.8	1.77	Pass	Pass	Pass	OFDM	N/A	Pass
5 200	2015.01.17	3879	5 200	Head	52.2	2.02	Pass	Pass	Pass	OFDM	N/A	Pass
5 800	2015.01.19	3879	5 800	Head	36.8	4.52	Pass	Pass	Pass	OFDM	N/A	Pass
2 450	2015.01.21	3879	2 450	Body	47.9	5.23	Pass	Pass	Pass	OFDM	N/A	Pass
5 200	2015.01.20	3879	5 200	Body	34.5	5.21	Pass	Pass	Pass	OFDM	N/A	Pass
5 800	2015.01.19	3879	5 800	Body	48.6	5.95	Pass	Pass	Pass	OFDM	N/A	Pass

6. RF exposure limits

Uncontrolled environment

Uncontrolled environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

Controlled environment

Controlled environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

	Uncontrolled environment general population (W/kg) or (㎽/g)	**Controlled environment occupational (W/kg) or (㎽/g)**
Spatial peak SAR head	1.60	8.00
Spatial average SAR whole body	0.08	0.40
Spatial peak SAR hands, feet, ankles, wrists	4.00	20.00

Figure 12. RF exposure limits

7. Test results summary

7.1. RF conducted power

7.1.1. Power measurement procedures

The SAR measurement software calculates a reference point at the start and end of the test to check for power drifts. If conducted power deviations of more than 5 % occurred, the tests were repeated.

7.1.2. RF conducted power

Band	Mode	Bandwidth (㎒)	Channel	Data rate	Frequency (㎒)	Measured output power	
						Ant. 1(dBm)	Ant. 2(dBm)
2.4 ㎓	802.11b	20	1	1	2 412	16.74	16.71
			6	1	2 437	16.91	16.74
			11	1	2 462	14.52	14.95
	802.11g	20	1	6	2 412	9.95	10.36
			6	6	2 437	10.28	9.79
			11	6	2 462	8.49	8.92
	802.11n	20	1	6.5	2 412	9.89	10.21
			6	6.5	2 437	10.02	9.51
			11	6.5	2 462	8.87	9.76
		40	3	13.5	2 422	8.56	8.45
			6	13.5	2 437	8.88	7.97
			9	13.5	2 452	7.09	7.59
5.2 ㎓	802.11a	20	36	6	5 180	9.81	10.28
			40	6	5 200	9.92	10.73
			44	6	5 220	10.06	10.12
			48	6	5 240	10.29	10.41
	802.11n	20	36	6.5	5 180	9.75	10.22
			40	6.5	5 200	9.84	10.85
			44	6.5	5 220	9.84	10.05
			48	6.5	5 240	9.86	10.49
		40	38	13.5	5 190	10.08	10.18
			46	13.5	5 230	10.29	10.32
5.8 ㎓	802.11a	20	149	6	5 745	10.97	12.06
			153	6	5 765	12.46	12.34
			157	6	5 785	13.00	13.54
			161	6	5 805	12.51	13.09
			165	6	5 825	12.09	13.16
	802.11n	20	149	6.5	5 745	10.27	11.10
			153	6.5	5 765	11.55	11.46
			157	6.5	5 785	12.96	12.94
			161	6.5	5 805	12.37	12.03
			165	6.5	5 825	12.09	13.01
		40	151	13.5	5 755	10.54	11.70
			159	13.5	5 795	13.01	13.09

Note;

1. All data rates were measured each band/bandwidth and the highest power data rates were reported.

7.2. SAR results

7.2.1. Measured and reported SAR

According to the FCC KDB publication 447498 D01v05r02, when SAR is not measured at the maximum power level allowed for production units, the results must be scaled to the maximum tune-up tolerance limit according to the power applied to the individual channels tested to determine compliance. If the device is possible simultaneous transmission, the measured aggregate SAR must be scaled according to the sum of the differences between the maximum tune-up tolerance and actual power used to test each transmitter. When SAR is measured at or scaled to the maximum tune-up tolerance limit, the results are referred to as reported SAR. The highest reported SAR results are identified on the grant of equipment authorization according to procedure in KDB 690783 D01v01r03

802.11 a/b/g and 4.9 ㎓ operating modes are tested independently according to the service requirements in each frequency band. 802.11 b/g modes are tested on channel 1, 6, and 11. 802.11a is tested for UNII operations on channels 36 and 48 in the 5.15 ~ 5.25 ㎓ band, channels 52 and 64 in the 5.25 ~ 5.35 ㎓ band, channels 104, 116, 124 and 136 in the 5.470 ~ 5.725 ㎓ band, and channels 149 and 161 in the 5.8 ㎓ band. When 5.8 ㎓ §15.247 is also available, channels 149, 157 and 165 should be tested instead of the UNII channels.

SAR is not required for 802.11g channels when the maximum average output power is less than ¼ dB higher than that measured on the corresponding 802.11b channels.
The average output power for 802.11a should be measured on all channels in each frequency band. When the maximum average output channel in each frequency band is not included in the "default test channels", the maximum channel should be tested instead of an adjacent "default test channel".

Mode		GHz	Channel	Turbo Channel	"Default Test Channels"			
					§15.247		UNII	
					802.11b	802.11g		
802.11 b/g		2.412	1#		√	∇		
		2.437	6	6	√	∇		
		2.462	11#		√	∇		
802.11a	UNII	5.18	36				√	
		5.20	40	42 (5.21 GHz)				*
		5.22	44					*
		5.24	48	50 (5.25 GHz)			√	
		5.26	52				√	
		5.28	56	58 (5.29 GHz)				*
		5.30	60					*
		5.32	64				√	
		5.500	100	Unknown				*
		5.520	104				√	
		5.540	108					*
		5.560	112					*
		5.580	116				√	
		5.600	120					*
		5.620	124				√	
		5.640	128					*
		5.660	132					*
		5.680	136				√	
		5.700	140					*
	UNII or §15.247	5.745	149		√		√	
		5.765	153	152 (5.76 GHz)		*		*
		5.785	157		√			*
		5.805	161	160 (5.80 GHz)		*	√	
	§15.247	5.825	165		√			

Table 1: "Default Test Channels"

- √ = "default test channels"
- * = possible 802.11a channels with maximum average output > the "default test channels"
- ∇ = possible 802.11g channels with maximum average output ¼ dB ≥ the "default test channels"
- # = when output power is reduced for channel 1 and/or 11 to meet restricted band requirements the highest output channels closest to each of these channels should be tested

7.2.2. WLAN 2.4 ㎓ band

Test mode	Antenna (0/1)	EUT position	Frequency (㎒)	Channel	Distance (mm)	Power(㏈m)		SAR$_{1g}$(W/kg)	
						Measured power	Tune up limit	Measured SAR	Scaled SAR
802.11b (Head)	1	Front	2 437	6	0	16.91	17.00	0.079	**0.081**
	2	Front	2 437	6	0	16.74	17.00	0.059	0.063
802.11b (Body)	1	Front	2 437	6	0	16.91	17.00	0.062	0.063
	2	Front	2 437	6	0	16.74	17.00	0.031	0.033

7.2.3. WLAN 5.2 ㎓ band

Test mode	Antenna (0/1)	EUT position	Frequency (㎒)	Channel	Distance (mm)	Power(㏈m)		SAR$_{1g}$(W/kg)	
						Measured power	Tune up limit	Measured SAR	Scaled SAR
802.11a (Head)	1	Front	5 180	36	0	9.81	10.00	0.012	0.013
	1	Front	5 240	48	0	10.29	11.00	0.012	0.014
	2	Front	5 180	36	0	10.28	11.00	0.013	0.015
	2	Front	5 240	48	0	10.41	11.00	0.016	0.018
802.11a (Body)	1	Front	5 180	36	0	9.81	10.00	0.00827	0.009
	1	Front	5 240	48	0	10.29	11.00	0.0078	0.009
	2	Front	5 180	36	0	10.28	11.00	0.00971	0.011
	2	Front	5 240	48	0	10.41	11.00	0.012	0.014

7.2.4. WLAN 5.8 ㎓ band

Test mode	Antenna (0/1)	EUT position	Frequency (㎒)	Channel	Distance (mm)	Power(㏈m)		SAR$_{1g}$(W/kg)	
						Measured power	Tune up limit	Measured SAR	Scaled SAR
802.11a (Head)	1	Front	5 745	149	0	10.97	11.00	0.020	0.020
	1	Front	5 785	157	0	13.00	14.00	0.023	0.029
	1	Front	5 825	165	0	12.09	13.00	0.027	0.033
	2	Front	5 745	149	0	12.06	13.00	0.016	0.020
	2	Front	5 785	157	0	13.54	14.00	0.030	0.033
	2	Front	5 825	165	0	13.16	14.00	0.028	0.034
802.11a (Body)	1	Front	5 745	149	0	10.97	11.00	0.019	0.019
	1	Front	5 785	157	0	13.00	14.00	0.019	0.024
	1	Front	5 825	165	0	12.09	13.00	0.017	0.021
	2	Front	5 745	149	0	12.06	13.00	0.013	0.016
	2	Front	5 785	157	0	13.54	14.00	0.031	0.034
	2	Front	5 825	165	0	13.16	14.00	0.022	0.027

Note:

1. The test data reported are worst case SAR values according to test procedure specified in IEEE 1528-2003,FCC KDB publication 865664 D01v01r03 and 447498 D01v05r02.
2. All mode of operation were investigated and worst case results are reported.
3. Battery is fully charged at the beginning of the SAR measurements
4. Liquid tissue depth was at least 15 cm for all frequencies.
5. The manufacturer has confirmed that device(s) tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units.
6. According to the FCC KDB publication 865664 D01v01r03, variability SAR tests are required if the measured SAR results for the frequency band are more than 0.8 W/kg.
7. SAR results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB publication 447498 D01v05r02.
8. Justification for reduced test configurations for WIFI channels per KDB Publication 248227 D01v01r02 and October 2012 FCC/TCB Meeting Notes for 2.4 ㎓ WIFI: Highest average RF output power channel for the lowest data rate was selected for SAR evaluation in 802.11b. Other IEEE 802.11 modes (including 802.11g/n) were not investigated since the average output powers over all channels and data rates were not more than 0.25 ㏈ higher than the tested channel in the lowest data rate of IEEE 802.11b mode
9. Justification for reduced test configurations for WIFI channels per KDB Publication 248227 D01v01r02 and October 2012 FCC/TCB Meeting Notes for 5 ㎓ WIFI: Highest average RF output power channel for the lowest data rate was selected for SAR evaluation in 802.11a. Other IEEE 802.11 modes (including 802.11n) were not investigated since the average output powers over all channels and data rates were not more than 0.25 ㏈ higher than the tested channel in the lowest data rate of IEEE 802.11a mode.
10. When the maximum extrapolated peak SAR of the zoom scan for the maximum output channel was <1.6 W/kg and the reported 1g averaged SAR is <0.8 W/kg, SAR testing on other default channels was required.

8. Measurement equipments

Equipment	Manufacturer	Model	Serial No.	Calibration interval	Calibration due.
Stäubli Robot Unit	Stäubli	RX90B	F02/5Q89A1/A/01	N/A	N/A
Data Acquisition Electronics	SPEAG	DAE4	1344	1year	2015.11.12
E-Field Probe	SPEAG	EX3DV4	3879	1year	2015.11.19
Electro Optical Converter	SPEAG	EOC5	N/A	N/A	N/A
2mm Oval Phantom ELI5	SPEAG	QD OVA 002 AA	1190	N/A	N/A
Dipole Antenna	SPEAG	D2450V2	896	3years	2017.05.20
Dipole Antenna	SPEAG	D5GHzV2	1130	3years	2017.05.22
S-Parameter Network Analyzer	Agilent	8753ES	MY40000210	1year	2015.07.23
Calibration Kit	Agilent	85033D	3423A02429	N/A	N/A
EPM Series Power Meter	HP	E4419B	GB37290599	1year	2015.07.23
E-Series AVG Power Sensor	HP	E9300H	MY41495967	1year	2015.07.23
E-Series AVG Power Sensor	HP	E9300H	US39215405	1year	2015.07.23
Power Meter	Anritsu	ML2495A	1438001	1year	2016.01.22
Pulse Power Sensor	Anritsu	MA2411B	1339205	1year	2016.01.22
Broadband High Power Amplifier	EM Power	1138	1030	1year	2015.07.23
Dual Directional Coupler	HP	11692D	1212A03523	1year	2015.07.24
Vector Signal Generator	R&S	SMBV100A	1407.6004K02	1year	2015.07.24
Signal Analyzer	R&S	FSV30	101389	1year	2016.01.22
Attenuator	HP	8494B	2630A12857	1year	2016.01.22
Hygro-Thermometer	BODYCOM	BJ5478	N/A	1year	2015.07.28
Dielectric Probe Kit	Agilent	85070E	MY44300696	N/A	N/A
Software	SPEAG	DASY4 V4.7	-	N/A	N/A

9. Measurement Uncertainty

DASY4 Uncertainty budget							
Error Description	**Section in P1528**	**Uncertainty Value ± %**	**Prob. Dist.**	**Div.**	c_i **(1 g)**	$u_i(y)$ **(1 g) ± %**	v_i **or** v_{eff}
Probe Calibration	E.2.1	6.55	N	1.00	1.00	6.55	∞
Axial Isotropy	E.2.2	0.50	R	1.73	0.71	0.20	∞
Hemispherical Isotropy	E.2.2	2.60	R	1.73	0.71	1.06	∞
Boundary Effect	E.2.3	2.00	R	1.73	1.00	1.16	∞
Linearity	E.2.4	0.60	R	1.73	1.00	0.35	∞
System Detection Limits	E.2.5	1.00	R	1.73	1.00	0.58	∞
Readout Electronics	E.2.6	0.30	N	1.00	1.00	0.30	∞
Response Time	E.2.7	0.50	R	1.73	1.00	0.29	∞
Integration Time	E.2.8	2.60	R	1.73	1.00	1.50	∞
RF Ambient Noise	E.6.1	3.00	R	1.73	1.00	1.73	∞
RF Ambient Reflections	E.6.1	3.00	R	1.73	1.00	1.73	∞
Probe Positioning Mechanical Tolerance	E.6.2	0.40	R	1.73	1.00	0.23	∞
Probe Positioning With Respect to Phantom	E.6.3	2.90	R	1.73	1.00	1.67	∞
Max. SAR Eval.	E.5.2	2.00	R	1.73	1.00	1.15	∞
Test sample positioning	E.4.2	2.30	N	1.00	1.00	2.30	9
Device Holder Uncertainty	E.4.1	3.60	N	1.00	1.00	3.60	∞
SAR Drift Measurement	6.6.3	5.00	R	1.73	1.00	2.89	∞
Phantom Uncertainty	E.3.1	6.10	R	1.73	1.00	3.52	∞
Liquid Conductivity(target)	E.3.2	5.00	R	1.73	0.64	1.85	∞
Liquid Conductivity(meas.)	E.3.2	0.30	N	1.00	0.64	0.19	5
Liquid Permittivity(target)	E.3.3	5.00	R	1.73	0.60	1.73	∞
Liquid Permittivity(meas.)	E.3.3	0.01	N	1.00	0.60	0.01	5
Combined Std. Uncertainty(RSS)						± 10.19 %	10 301.933
Expanded Uncertainty						± 20.38 %	***k*** **= 2**

Appendix list
Appendix A. DASY4 report
Appendix B. Calibration certificate