



SAR EVALUATION REPORT


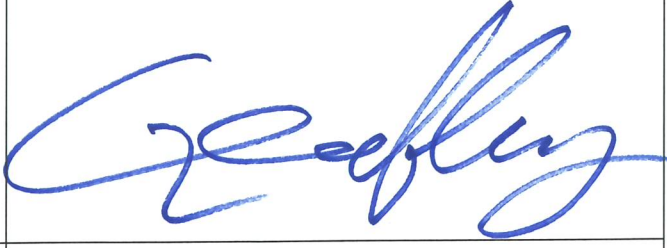
Equipment under test Flat Panel Detector
Model name FXRD-1012NAW
Derivative model FXRD-1012NBW
FCC ID PFRFXRD-1012NAW
Module FCC ID RYK-WPEA-121N
Applicant Vieworks Co., Ltd.
Manufacturer Vieworks Co., Ltd.
Date of test(s) 2015.01.17 ~ 2015.01.21
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Revision history

| Revision | Date of issue | Test report No. | Description |
|----------|---------------|-------------------|-------------------------------------|
| - | 2015.01.29 | KES-SR-15T0003 | Initial |
| | 2015.08.24 | KES-SR-15T0003-R1 | A revision by typo of power current |

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1. General information

1.1. EUT description

| | |
|--------------------------------|--|
| Equipment under test | Flat Panel Detector |
| Model name | FXRD-1012NAW |
| Serial number | N/A |
| Frequency range | 2 412 MHz ~ 2 462 MHz: 11 channel (802.11 b/g/n_HT20) 2 422 MHz ~ 2 452 MHz: 9 channel (11n_HT40) 5 745 MHz ~ 5 825 MHz: 5 channel (11a/n_HT20_Non DFS) 5 755 MHz ~ 5 795 MHz: 2 channel (11n_HT40_Non DFS) 5 180 MHz ~ 5 240 MHz: 4 channel (11a/n_HT20_Non DFS) 5 190 MHz ~ 5 230 MHz: 2 channel (11n_HT40_Non DFS) |
| Body worn accessory | None |
| Antenna type & gain | PCB antenna |
| Power source | 24 V // 0.8A |

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 GHz band | Head | 0.026 |
| | | Body | 0.027 |
| | WLAN 5.8 GHz band | Head | 0.138 |
| | | Body | 0.071 |
| UNII | WLAN 5.2 GHz band | Head | 0.01144 |
| | | Body | 0.00838 |
| Simultaneous transmission SAR per KDB 690783 D01v01r03 | | | N/A |

Notes:

1. WLAN 2.4 GHz band and 5 GHz band share same the 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 (MHz) | Channel | Frequency (MHz) | Maximum output power | | | | |
|---------|---------|-----------------|---------|-----------------|----------------------|-------------|-------|-------|-------|
| | | | | | Ant. 1(dBm) | Ant. 2(dBm) | | | |
| 2.4 GHz | 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 GHz | 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 GHz | 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 GHz)
- 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 D02v01r01 (SAR reporting)

1.5. Test conditions

| | |
|---------------------------------|-----------------|
| Ambient temperature | (22 ± 2) °C |
| Tissue simulating liquid | (22 ± 2) °C |
| 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).

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

Figure 1. SAR Mathematical equation

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

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

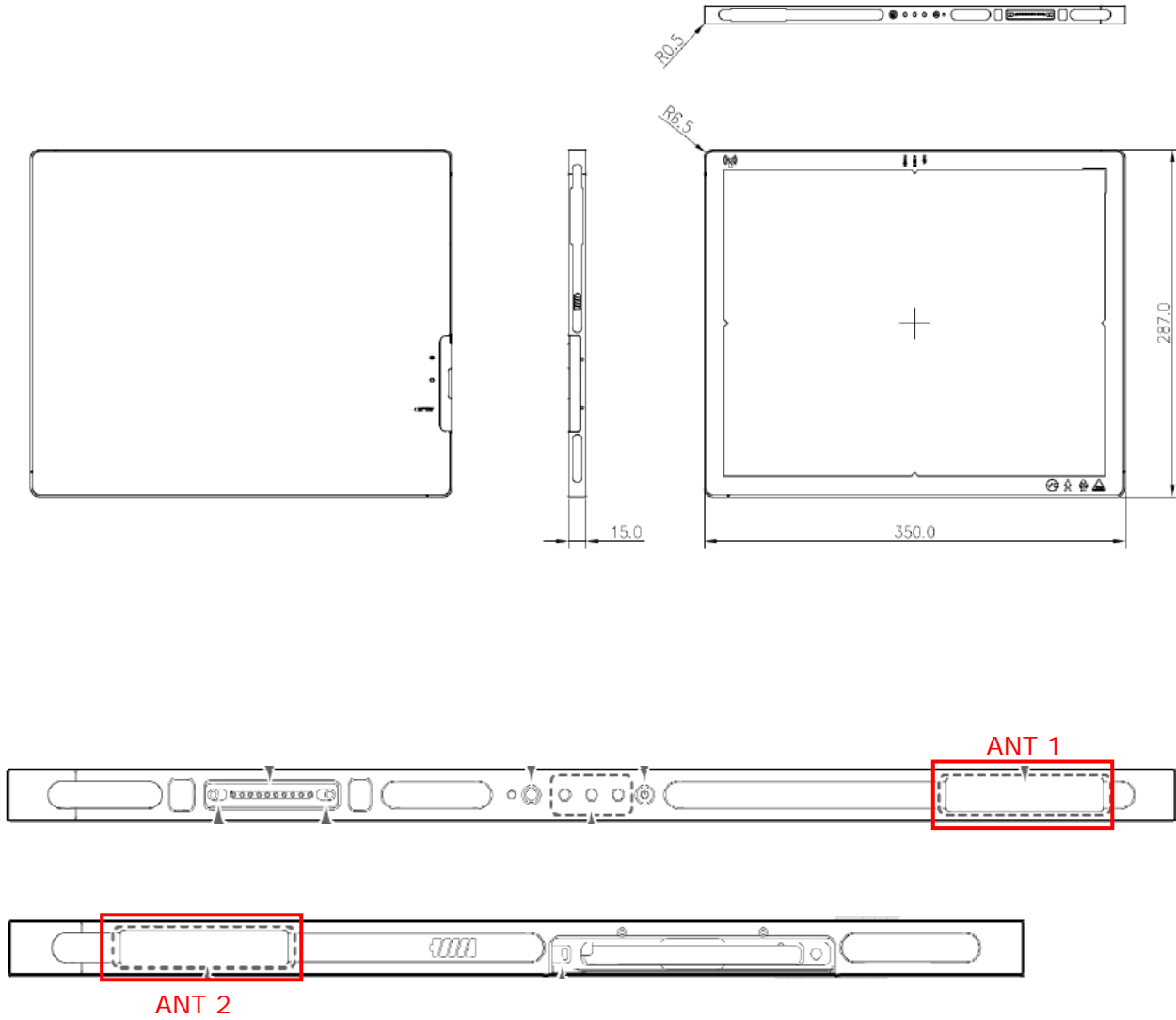
Where:

- σ = Conductivity of the tissue-simulating material (S/m)
- ρ = Mass density of the tissue-simulating material (kg/m³)
- 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

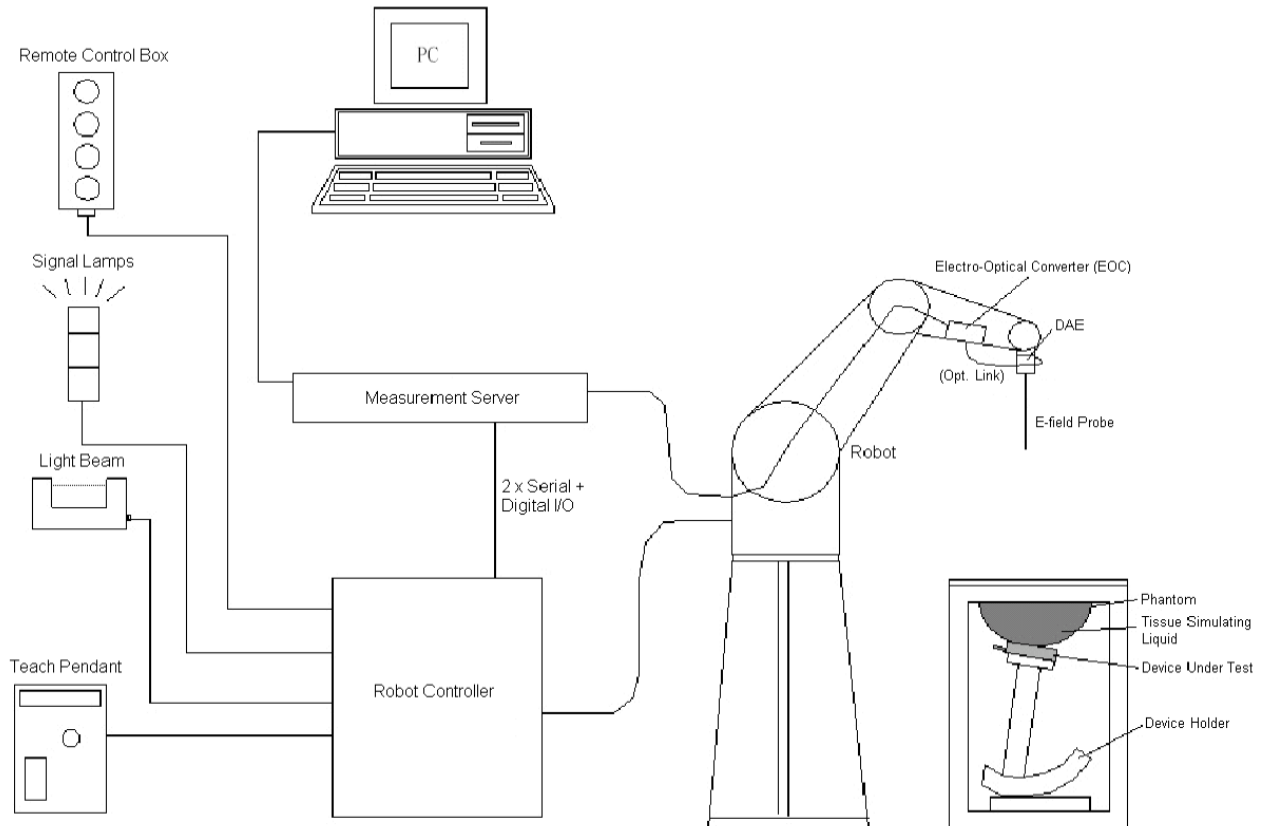


Figure 2. SPEAG DASY system configuration

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
- Remote control with teach pendant and additional circuitry for robot safety such as warning 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 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz) | |
| Directivity | ± 0.3 dB in TSL (rotation around probe axis) ± 0.5 dB in TSL (rotation normal to probe axis) | |
| Dynamic Range | 10 μ W/g to > 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 μ W/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, 400mV) | |
| 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



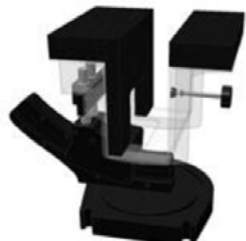
| | | |
|------------------------|---|---|
| Model | ELI |  |
| Construction | Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has 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 |  <p>Figure 8. Mounting device</p> |
| 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 | |

| | | |
|---------------------|---|--|
| Model | Laptop extensions kit |  <p>Figure 9. Laptop extensions kit</p> |
| 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 | |

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 mm. 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.

| | | ≤ 3 GHz | > 3 GHz |
|--|------------------------------------|--|---|
| Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface | | 5 ± 1 mm | $\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm |
| Maximum probe angle from probe axis to phantom surface normal at the measurement location | | $30^\circ \pm 1^\circ$ | $20^\circ \pm 1^\circ$ |
| Maximum area scan spatial resolution: $\Delta x_{Area}, \Delta y_{Area}$ | | ≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm | 3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm |
| | | 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. | |
| Maximum zoom scan spatial resolution: $\Delta x_{Zoom}, \Delta y_{Zoom}$ | | ≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm* | 3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm* |
| Maximum zoom scan spatial resolution, normal to phantom surface | uniform grid: $\Delta z_{Zoom}(n)$ | ≤ 5 mm | 3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm |
| | graded grid | $\Delta z_{Zoom}(1)$: between 1 st two points closest to phantom surface $\Delta z_{Zoom}(n>1)$: between subsequent points | ≤ 4 mm $\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$ |
| | x, y, z | ≥ 30 mm | 3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm |
| <p>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.</p> <p>* When zoom scan is required and the <i>reported</i> SAR from the <i>area scan based 1-g SAR estimation</i> procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 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.</p> | | | |

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.

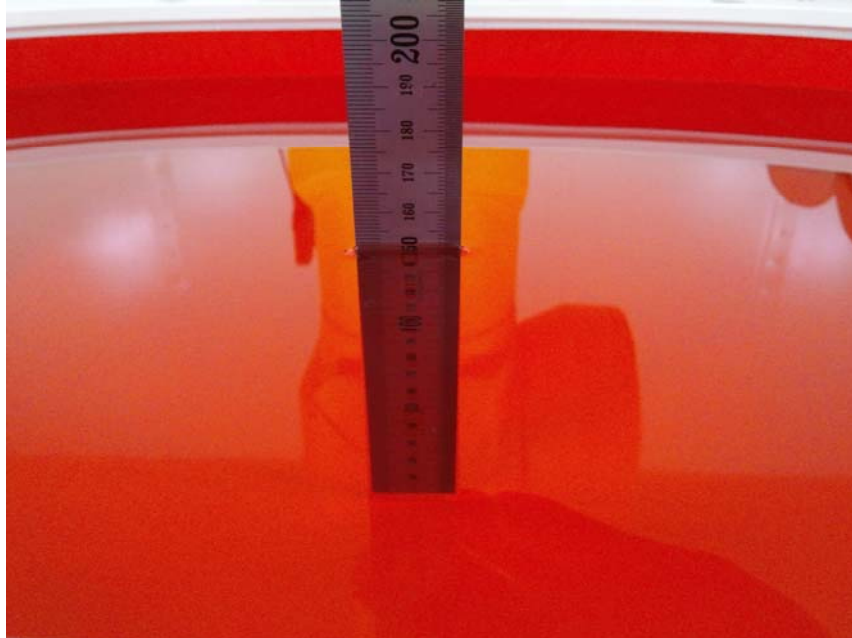


Figure 11. Liquid height photo

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 GHz band

| Frequency (MHz) | Tissue type | Liquid temp.(°C) | Parameters | Target value | Measured value | Deviation (%) | Limit (%) | Data |
|-----------------|-------------|------------------|--------------------------------|--------------|----------------|---------------|-----------|------------|
| 2 450 | Head | 22.0 | Permittivity (ε _r) | 39.20 | 39.20 | 0.00 | ±5 | 2015.01.21 |
| | | | Conductivity (σ) | 1.80 | 1.84 | 2.22 | ±5 | 2015.01.21 |
| 2 437 | Head | 22.0 | Permittivity (ε _r) | - | 39.20 | 0.00 | ±5 | 2015.01.21 |
| | | | Conductivity (σ) | - | 1.83 | 1.67 | ±5 | 2015.01.21 |
| 2 450 | Body | 22.0 | Permittivity (ε _r) | 52.70 | 51.60 | -2.09 | ±5 | 2015.01.21 |
| | | | Conductivity (σ) | 1.95 | 2.03 | 4.10 | ±5 | 2015.01.21 |
| 2 437 | Body | 22.0 | Permittivity (ε _r) | - | 51.60 | -2.09 | ±5 | 2015.01.21 |
| | | | Conductivity (σ) | - | 2.02 | 3.59 | ±5 | 2015.01.21 |

WLAN 5.2 GHz band

| Frequency (MHz) | Tissue type | Liquid temp.(°C) | Parameters | Target value | Measured value | Deviation (%) | Limit (%) | Data |
|-----------------|-------------|------------------|--------------------------------|--------------|----------------|---------------|-----------|------------|
| 5 200 | Head | 22.0 | Permittivity (ε _r) | 36.00 | 35.70 | -0.83 | ±5 | 2015.01.17 |
| | | | Conductivity (σ) | 4.66 | 4.58 | -1.72 | ±5 | 2015.01.17 |
| 5 180 | Head | 22.0 | Permittivity (ε _r) | - | 35.70 | -0.83 | ±5 | 2015.01.17 |
| | | | Conductivity (σ) | - | 4.57 | -1.93 | ±5 | 2015.01.17 |
| 5 240 | Head | 22.0 | Permittivity (ε _r) | - | 35.80 | -0.56 | ±5 | 2015.01.17 |
| | | | Conductivity (σ) | - | 4.60 | -1.29 | ±5 | 2015.01.17 |
| 5 200 | Body | 22.0 | Permittivity (ε _r) | 49.00 | 47.40 | -3.27 | ±5 | 2015.01.20 |
| | | | Conductivity (σ) | 5.30 | 5.06 | -4.53 | ±5 | 2015.01.20 |
| 5 180 | Body | 22.0 | Permittivity (ε _r) | - | 47.30 | -3.47 | ±5 | 2015.01.20 |
| | | | Conductivity (σ) | - | 5.05 | -4.72 | ±5 | 2015.01.20 |
| 5 240 | Body | 22.0 | Permittivity (ε _r) | - | 47.40 | -3.27 | ±5 | 2015.01.20 |
| | | | Conductivity (σ) | - | 5.13 | -3.21 | ±5 | 2015.01.20 |

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WLAN 5.8 GHz band

| Frequency (MHz) | Tissue type | Liquid temp.(°C) | Parameters | Target value | Measured value | Deviation (%) | Limit (%) | Data |
|-----------------|-------------|------------------|-------------------------------|--------------|----------------|---------------|-----------|------------|
| 5 800 | Head | 22.0 | Permittivity (ϵ_r) | 35.30 | 35.20 | -0.28 | ± 5 | 2015.01.19 |
| | | | Conductivity (σ) | 5.27 | 5.39 | 2.28 | ± 5 | 2015.01.19 |
| 5 745 | Head | 22.0 | Permittivity (ϵ_r) | - | 35.30 | 0.00 | ± 5 | 2015.01.19 |
| | | | Conductivity (σ) | - | 5.26 | -0.19 | ± 5 | 2015.01.19 |
| 5 785 | Head | 22.0 | Permittivity (ϵ_r) | - | 35.30 | 0.00 | ± 5 | 2015.01.19 |
| | | | Conductivity (σ) | - | 5.37 | 1.90 | ± 5 | 2015.01.19 |
| 5 825 | Head | 22.0 | Permittivity (ϵ_r) | - | 35.30 | 0.00 | ± 5 | 2015.01.19 |
| | | | Conductivity (σ) | - | 5.41 | 2.66 | ± 5 | 2015.01.19 |
| 5 800 | Body | 22.0 | Permittivity (ϵ_r) | 48.20 | 49.70 | 3.11 | ± 5 | 2015.01.19 |
| | | | Conductivity (σ) | 6.00 | 6.18 | 3.00 | ± 5 | 2015.01.19 |
| 5 745 | Body | 22.0 | Permittivity (ϵ_r) | - | 49.80 | 3.32 | ± 5 | 2015.01.19 |
| | | | Conductivity (σ) | - | 6.07 | 1.67 | ± 5 | 2015.01.19 |
| 5 785 | Body | 22.0 | Permittivity (ϵ_r) | - | 49.70 | 3.11 | ± 5 | 2015.01.19 |
| | | | Conductivity (σ) | - | 6.12 | 2.00 | ± 5 | 2015.01.19 |
| 5 825 | Body | 22.0 | Permittivity (ϵ_r) | - | 49.60 | 2.90 | ± 5 | 2015.01.19 |
| | | | Conductivity (σ) | - | 6.18 | 3.00 | ± 5 | 2015.01.19 |

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5. System verification and validation

5.1. Procedure

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

- Cabling the system, using the verification kit equipments.
- Generate about 100 mW or 250 mW 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 (MHz) | 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 | 12.10 | 48.4 | -7.98 | ± 10 | 2015.01.21 |
| | Body | 3879 | 896 | 50.6 | 12.50 | 50.0 | -1.19 | ± 10 | 2015.01.21 |
| 5 200 | Head | 3879 | 1130 | 79.4 | 8.37 | 83.7 | 5.42 | ± 10 | 2015.01.17 |
| | Body | 3879 | 1130 | 76.1 | 7.67 | 76.7 | 0.79 | ± 10 | 2015.01.20 |
| 5 800 | Head | 3879 | 1130 | 81.0 | 8.24 | 82.4 | 1.73 | ± 10 | 2015.01.19 |
| | Body | 3879 | 1130 | 77.6 | 8.30 | 83.0 | 6.96 | ± 10 | 2015.01.19 |

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 | 39.20 | 1.84 | Pass | Pass | Pass | OFDM | N/A | Pass |
| 5 200 | 2015.01.17 | 3879 | 5 200 | Head | 35.70 | 4.58 | Pass | Pass | Pass | OFDM | N/A | Pass |
| 5 800 | 2015.01.19 | 3879 | 5 800 | Head | 35.20 | 5.39 | Pass | Pass | Pass | OFDM | N/A | Pass |
| 2 450 | 2015.01.21 | 3879 | 2 450 | Body | 51.60 | 2.03 | Pass | Pass | Pass | OFDM | N/A | Pass |
| 5 200 | 2015.01.20 | 3879 | 5 200 | Body | 47.40 | 5.06 | Pass | Pass | Pass | OFDM | N/A | Pass |
| 5 800 | 2015.01.19 | 3879 | 5 800 | Body | 49.70 | 6.18 | Pass | Pass | Pass | OFDM | N/A | Pass |

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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 (mW/g) | Controlled environment occupational (W/kg) or (mW/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 (MHz) | Channel | Data rate | Frequency (MHz) | Measured output power | | | | |
|---------|---------|-----------------|---------|-----------|-----------------|-----------------------|-------------|-------|-------|-------|
| | | | | | | Ant. 1(dBm) | Ant. 2(dBm) | | | |
| 2.4 GHz | 802.11b | 20 | 1 | 1 | 2 412 | 16.73 | 16.70 | | | |
| | | | 6 | 1 | 2 437 | 16.94 | 16.72 | | | |
| | | | 11 | 1 | 2 462 | 14.55 | 14.91 | | | |
| | 802.11g | 20 | 1 | 6 | 2 412 | 9.96 | 10.31 | | | |
| | | | 6 | 6 | 2 437 | 10.23 | 9.70 | | | |
| | | | 11 | 6 | 2 462 | 8.42 | 8.97 | | | |
| | 802.11n | 20 | 1 | 6.5 | 2 412 | 9.85 | 10.28 | | | |
| | | | 6 | 6.5 | 2 437 | 10.05 | 9.59 | | | |
| | | | 11 | 6.5 | 2 462 | 8.85 | 9.78 | | | |
| | | 40 | 3 | 13.5 | 2 422 | 8.55 | 8.43 | | | |
| | | | 6 | 13.5 | 2 437 | 8.83 | 7.90 | | | |
| | | | 9 | 13.5 | 2 452 | 7.08 | 7.53 | | | |
| 5.2 GHz | 802.11a | 20 | 36 | 6 | 5 180 | 9.83 | 10.25 | | | |
| | | | 40 | 6 | 5 200 | 9.90 | 10.71 | | | |
| | | | 44 | 6 | 5 220 | 10.05 | 10.10 | | | |
| | | | 48 | 6 | 5 240 | 10.24 | 10.48 | | | |
| | 802.11n | 20 | 36 | 6.5 | 5 180 | 9.73 | 10.29 | | | |
| | | | 40 | 6.5 | 5 200 | 9.87 | 10.80 | | | |
| | | | 44 | 6.5 | 5 220 | 9.82 | 10.08 | | | |
| | | | 48 | 6.5 | 5 240 | 9.88 | 10.46 | | | |
| | | 40 | 38 | 13.5 | 5 190 | 10.03 | 10.16 | | | |
| | | | 46 | 13.5 | 5 230 | 10.22 | 10.36 | | | |
| | | | 5.8 GHz | 802.11a | 20 | 149 | 6 | 5 745 | 10.91 | 12.05 |
| | | | | | | 153 | 6 | 5 765 | 12.48 | 12.36 |
| 157 | 6 | 5 785 | | | | 13.01 | 13.51 | | | |
| 161 | 6 | 5 805 | | | | 12.50 | 13.04 | | | |
| 165 | 6 | 5 825 | | | | 12.03 | 13.18 | | | |
| 802.11n | 20 | 149 | | 6.5 | 5 745 | 10.24 | 11.11 | | | |
| | | 153 | | 6.5 | 5 765 | 11.58 | 11.46 | | | |
| | | 157 | | 6.5 | 5 785 | 12.98 | 12.95 | | | |
| 40 | 161 | 6.5 | 5 805 | 12.34 | 12.05 | | | | | |
| | 165 | 6.5 | 5 825 | 12.00 | 13.06 | | | | | |
| 40 | 151 | 13.5 | 5 755 | 10.57 | 11.77 | | | | | |
| | 159 | 13.5 | 5 795 | 13.03 | 13.08 | | | | | |

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Note;

- 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 GHz 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 GHz band, channels 52 and 64 in the 5.25 ~ 5.35 GHz band, channels 104, 116, 124 and 136 in the 5.470 ~ 5.725 GHz band, and channels 149 and 161 in the 5.8 GHz band. When 5.8 GHz §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 | 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 | 5.745 | 149 | | √ | | √ |
| | 5.765 | 153 | 152 (5.76 GHz) | | * | * |
| §15.247 | 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

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7.2.2. WLAN 2.4 GHz band

| Test mode | Antenna (0/1) | EUT position | Frequency (MHz) | Channel | Distance (mm) | Power(dBm) | | SAR _{1g} (W/kg) | |
|----------------|---------------|--------------|-----------------|---------|---------------|----------------|---------------|--------------------------|------------|
| | | | | | | Measured power | Tune up limit | Measured SAR | Scaled SAR |
| 802.11b (Head) | 1 | Front | 2 437 | 6 | 0 | 16.94 | 17.00 | 0.026 | 0.026 |
| | 2 | Front | 2 437 | 6 | 0 | 16.72 | 17.00 | 0.016 | 0.017 |
| 802.11b (Body) | 1 | Front | 2 437 | 6 | 0 | 16.94 | 17.00 | 0.027 | 0.027 |
| | 2 | Front | 2 437 | 6 | 0 | 16.72 | 17.00 | 0.018 | 0.019 |

7.2.3. WLAN 5.2 GHz band

| Test mode | Antenna (0/1) | EUT position | Frequency (MHz) | Channel | Distance (mm) | Power(dBm) | | SAR _{1g} (W/kg) | |
|----------------|---------------|--------------|-----------------|---------|---------------|----------------|---------------|--------------------------|------------|
| | | | | | | Measured power | Tune up limit | Measured SAR | Scaled SAR |
| 802.11a (Head) | 1 | Front | 5 180 | 36 | 0 | 9.83 | 10.00 | 0.011 | 0.01144 |
| | 1 | Front | 5 240 | 48 | 0 | 10.24 | 11.00 | 0.00499 | 0.00594 |
| | 2 | Front | 5 180 | 36 | 0 | 10.25 | 11.00 | 0.0065 | 0.00773 |
| | 2 | Front | 5 240 | 48 | 0 | 10.48 | 11.00 | 0.00855 | 0.00964 |
| 802.11a (Body) | 1 | Front | 5 180 | 36 | 0 | 9.83 | 10.00 | 0.00806 | 0.00838 |
| | 1 | Front | 5 240 | 48 | 0 | 10.24 | 11.00 | 0.00609 | 0.00725 |
| | 2 | Front | 5 180 | 36 | 0 | 10.25 | 11.00 | 0.00652 | 0.00775 |
| | 2 | Front | 5 240 | 48 | 0 | 10.48 | 11.00 | 0.00638 | 0.00719 |

7.2.4. WLAN 5.8 GHz band

| Test mode | Antenna (0/1) | EUT position | Frequency (MHz) | Channel | Distance (mm) | Power(dBm) | | SAR _{1g} (W/kg) | |
|----------------|---------------|--------------|-----------------|---------|---------------|----------------|---------------|--------------------------|--------------|
| | | | | | | Measured power | Tune up limit | Measured SAR | Scaled SAR |
| 802.11a (Head) | 1 | Front | 5 745 | 149 | 0 | 10.91 | 11.00 | 0.016 | 0.016 |
| | 1 | Front | 5 785 | 157 | 0 | 13.01 | 14.00 | 0.018 | 0.023 |
| | 1 | Front | 5 825 | 165 | 0 | 12.03 | 13.00 | 0.012 | 0.015 |
| | 2 | Front | 5 745 | 149 | 0 | 12.05 | 13.00 | 0.111 | 0.138 |
| | 2 | Front | 5 785 | 157 | 0 | 13.51 | 14.00 | 0.051 | 0.057 |
| | 2 | Front | 5 825 | 165 | 0 | 13.18 | 14.00 | 0.028 | 0.034 |
| 802.11a (Body) | 1 | Front | 5 745 | 149 | 0 | 10.91 | 11.00 | 0.019 | 0.019 |
| | 1 | Front | 5 785 | 157 | 0 | 13.01 | 14.00 | 0.022 | 0.028 |
| | 1 | Front | 5 825 | 165 | 0 | 12.03 | 13.00 | 0.012 | 0.015 |
| | 2 | Front | 5 745 | 149 | 0 | 12.05 | 13.00 | 0.057 | 0.071 |
| | 2 | Front | 5 785 | 157 | 0 | 13.51 | 14.00 | 0.057 | 0.064 |
| | 2 | Front | 5 825 | 165 | 0 | 13.18 | 14.00 | 0.034 | 0.041 |

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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 GHz 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 dB 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 GHz 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 dB 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 EL15 | 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 |

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9. Measurement Uncertainty

| DASY4 Uncertainty budget | | | | | | | |
|---|------------------|---------------------------|-------------|------|-------------|------------------------|---------------------------|
| Error Description | Section in P1528 | Uncertainty Value \pm % | Prob. Dist. | Div. | c_i (1 g) | $u_i(y)$ (1 g) \pm % | 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) | | | | | | \pm 10.19 % | 10 301.933 |
| Expanded Uncertainty | | | | | | \pm 20.38 % | $k = 2$ |

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Appendix list
Appendix A. DAS4 report
Appendix B. Calibration certificate