

## SAR Report

Applicant : Edimax Technology Co., Ltd.  
Applicant Address : No.278, Xinhua 1st Rd., Neihu Dist., Taipei City, Taiwan  
Product Type : 11ac 2T2R Wireless Dual-Band USB Adapter  
Trade Name : EDIMAX  
Model Number : EW-7822UAC V2.0A, EW-7822UAD  
Applicable Standard : IEEE Std. 1528-2013  
ANSI/IEEE C95.1  
47 CFR Part §2.1093  
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Taiwan Accreditation Foundation accreditation number: 1330  
Test Firm MRA designation number: TW0010

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### **Revision History**

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## 1. General Information

### 1.1 Reference Applicable Standard

| Standard            | Description   | Version |
|---------------------|---|---------|
| IEEE 1528           | IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head From Wireless Communications Devices: Measurement Techniques. | 2013    |
| ANSI/IEEE C95.1     | American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 300 KHz to 100 GHz, New York.                                  | 1992    |
| 47 CFR Part §2.1093 | Radiofrequency radiation exposure evaluation: portable devices.   | -       |
| KDB 248227 D01      | SAR guidance for IEEE 802.11 (Wi-Fi) transmitters   | v02r02  |
| KDB 447498 D01      | RF exposure procedures and equipment authorization policies for mobile and portable devices   | v06     |
| KDB 447498 D02      | SAR measurement procedures for usb dongle transmitters  | v02r01  |
| KDB 865664 D01      | SAR measurement requirement for 100 MHz to 6 GHz.   | v01r04  |
| KDB 865664 D02      | RF exposure compliance reporting and documentation considerations.  | v01r02  |

### 1.2 Test Site Environment

| Items            | Required (IEEE 1528-2013) | Actual |
|------------------|---------------------------|--------|
| Temperature (°C) | 18-25                     | 21-23  |



## 2. Summary of Maximum Reported SAR Value

| Equipment Class                       | Mode                | Highest Reported 1g SAR (W/kg)                     |
|---------------------------------------|---------------------|--|
|                                       |                     | Body standalone SAR <sub>1g</sub> (W/kg)           |
| DTS                                   | WLAN2.4GHz<br>Ant A | 0.81   |
|                                       | WLAN2.4GHz<br>Ant B | 0.74   |
| U-NII                                 | WLAN5GHz<br>Ant A   | 0.71   |
|                                       | WLAN5GHz<br>Ant B   | 0.77   |
| Highest Simultaneous Transmission SAR |                     | Highest Simultaneous Transmission 1g SAR<br>(W/kg) |
| Bottom of laptop at 0mm               |                     | <b>1.58</b>  |

Note:

The SAR limit (Head & Body: SAR<sub>1g</sub> 1.6 W/kg) for general population / uncontrolled exposure is specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1992.

### 3. Description of Equipment under Test (EUT)

|                  |   |                         |
|------------------|---|-------------------------|
| Applicant        | Edimax Technology Co., Ltd.<br>No.278, Xinhua 1st Rd., Neihu Dist., Taipei City, Taiwan |                         |
| Manufacturer     | Edimax Technology Co., Ltd.<br>No.278, Xinhua 1st Rd., Neihu Dist., Taipei City, Taiwan |                         |
| Product Type     | 11ac 2T2R Wireless Dual-Band USB Adapter  |                         |
| Trade Name       | EDIMAX  |                         |
| Model Number     | EW-7822UAC V2.0A, EW-7822UAD  |                         |
| FCC ID           | NDD9578222003   |                         |
| RF Function      | Operate Bands   | Operate Frequency (MHz) |
|                  | IEEE 802.11b / 802.11g / 802.11n 2.4 GHz 20 MHz   | 2412 - 2462             |
|                  | IEEE 802.11n 2.4 GHz 40 MHz   | 2422 - 2452             |
|                  | IEEE 802.11a  | 5180 - 5240             |
|                  |   | 5745 - 5825             |
|                  | IEEE 802.11n 5 GHz / 802.11ac 20 MHz  | 5180 - 5240             |
|                  |   | 5745 - 5825             |
|                  | IEEE 802.11n 5 GHz / 802.11ac 40 MHz  | 5190 - 5230             |
|                  |   | 5755 - 5795             |
|                  | IEEE 802.11ac 80 MHz  | 5210                    |
|                  |   | 5775                    |
| Device Category  | Portable Device   |                         |
| Application Type | Certification   |                         |

Note:

1. The above EUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.
2. When the antenna is built-in within the housing of a dongle, a swivel or rotating connector may allow the antenna to assume different positions. We evaluated the worst condition and obtained FCC approval and guidance testing.

#### Antenna list :

| Antenna Source |       | Model Name     | Type           | Frequency   | Max. Gain (dBi) |
|----------------|-------|----------------|----------------|-------------|-----------------|
| 1              | ANT-1 | GY121HT632-003 | Dipole antenna | 2402 - 2480 | 1.32            |
|                |       |                |                | 5150 - 5250 | 2.80            |
|                |       |                |                | 5725 - 5850 | 2.54            |
|                | ANT-2 | GY121HT632-003 | Dipole antenna | 2402 - 2480 | 2.09            |
|                |       |                |                | 5150 - 5250 | 2.26            |
|                |       |                |                | 5725 - 5850 | 4.37            |

## 4. Introduction

The A Test Lab Techno Corp. has performed measurements of the maximum potential exposure to the user. The test procedures, as described in American National Standards, Institute C95.1-1999 [ 1 ] were employed and they specify the maximum exposure limit of 1.6 W/kg as averaged over any 1 gram of tissue for portable devices being used within 20 cm between user and EUT in the uncontrolled environment. A description of the product and operating configuration, detailed summary of the test results, methodology and procedures used in the equipment used are included within this test report.

### 4.1 SAR Definition

Specific Absorption Rate (SAR) is defined as the time derivative (rate) of the incremental energy (dw) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density ( $\rho$ ). The equation description is as below :

$$SAR = \frac{d}{dt} \left( \frac{dw}{dm} \right) = \frac{d}{dt} \left( \frac{dw}{\rho dv} \right)$$

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

SAR measurement can be related to the electrical field in the tissue by

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

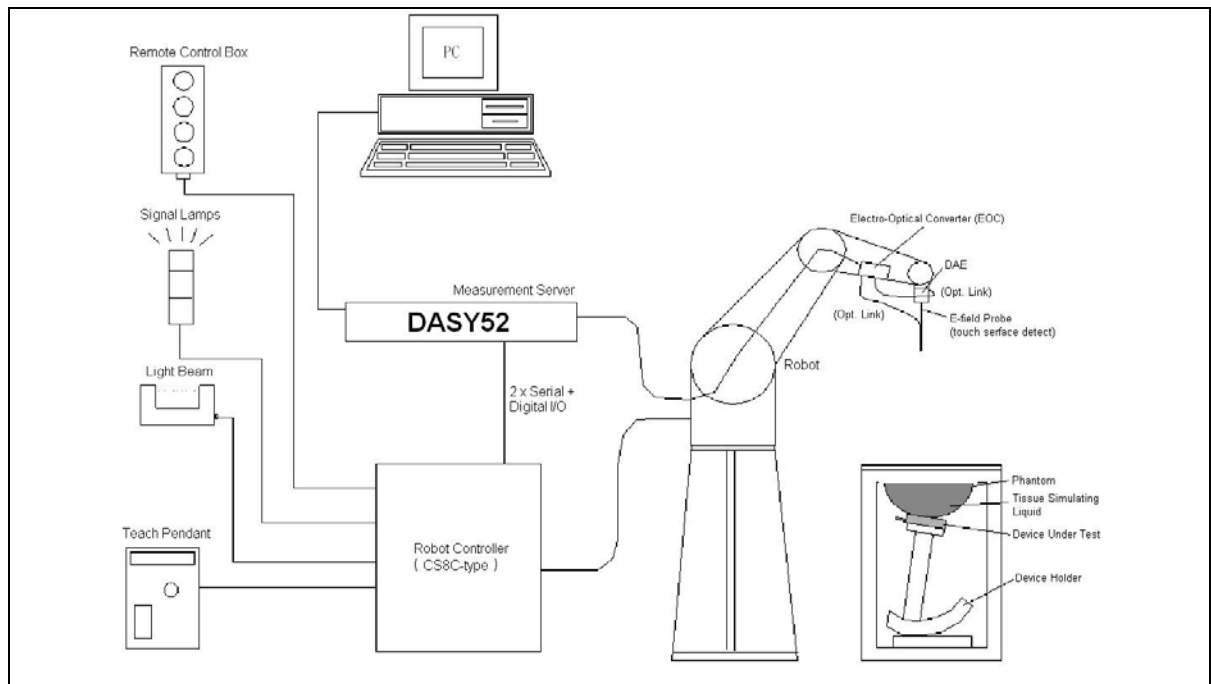
Where :

$\sigma$  = conductivity of the tissue (S/m)

$\rho$  = mass density of the tissue (kg/m<sup>3</sup>)

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

## 5. SAR Measurement Setup



The DASY52 system for performing compliance tests consists of the following items:


1. A standard high precision 6-axis robot (Stäubli TX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
2. An isotropic field probe optimized and calibrated for the targeted measurements.
3. A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
4. The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
5. The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
6. The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
7. A computer running Win7/Win8 professional operating system and the cDASY6 and DASY5 V5.2 software.
8. Remote controls with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
9. The phantom, the device holder and other accessories according to the targeted measurement.
10. Tissue simulating liquid mixed according to the given recipes.
11. The validation dipole has been calibrated within and the system performance check has been successful.




## 5.1 DASY E-Field Probe System

The SAR measurements were conducted with the dosimetric probe (manufactured by SPEAG), designed in the classical triangular configuration [3] and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multi-fiber line ending at the front of the probe tip. It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting. The approach is stopped when reaching the maximum.


### 5.1.1 E-Field Probe Specification

|   |   |
|---|---|
| <b>Construction</b>   | Symmetrical design with triangular core<br>Built-in shielding against static charges<br>PEEK enclosure material (resistant to organic solvents, e.g., DGBE) |
| <b>Frequency</b>  | 10 MHz to > 6 GHz<br>Linearity: $\pm 0.2$ dB (30 MHz to 6 GHz)  |
| <b>Directivity</b>  | $\pm 0.3$ dB in brain tissue (rotation around probe axis)<br>$\pm 0.5$ dB in brain tissue (rotation normal probe axis)                                      |
| <b>Dimensions</b>   | Overall length: 337 mm (Tip: 20 mm)<br>Tip diameter: 2.5 mm (Body: 12 mm)<br>Typical distance from probe tip to dipole centers: 1 mm                        |
| <b>Calibration</b>  | ISO/IEC 17025 calibration service available   |
| <div>   </div> |   |
| <div> <div>EX3DV4 E-Field Probe</div> <div>Probe setup on robot</div> </div>  |   |

## 5.2 Data Acquisition Electronic (DAE) System

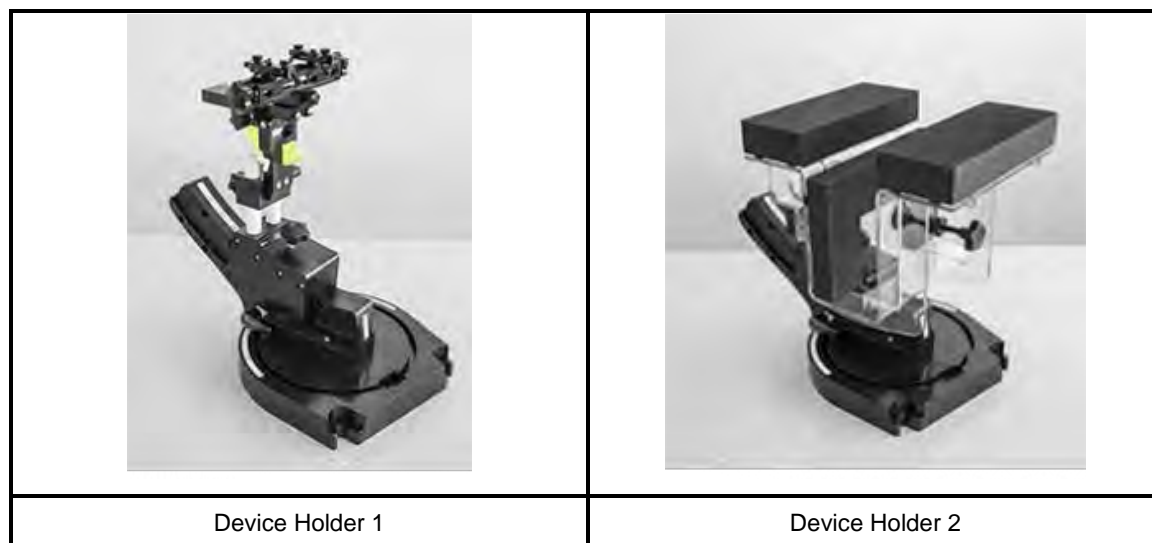
|                             |   |   |
|-----------------------------|---|---|
| <b>Model</b>                | DAE4  |  |
| <b>Construction</b>         | Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop. |   |
| <b>Measurement Range</b>    | -100 to +300 mV (16 bit resolution and two range settings: 4 mV, 400 mV)  |   |
| <b>Input Offset Voltage</b> | < 5 $\mu$ V (with auto zero)  |   |
| <b>Input Bias Current</b>   | < 50 fA   |   |
| <b>Dimensions</b>           | 60 x 60 x 68 mm   |   |

## 5.3 Robot

|                       |                         |   |
|-----------------------|-------------------------|---|
| <b>Positioner</b>     | Stäubli Unimation Corp. |  |
| <b>Robot Model</b>    | TX90XL                  |   |
| <b>Number of Axes</b> | 6                       |   |
| <b>Norminal Load</b>  | 5 kg                    |   |
| <b>Reach</b>          | 1450 mm                 |   |
| <b>Repeatability</b>  | $\pm$ 0.035 mm          |   |

## 5.4 Device Holder

The DASY device holder is constructed of low-loss POM material having the following dielectric parameters: relative permittivity  $\epsilon=3$  and loss tangent  $\delta=0.02$ . The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.



## 5.5 Oval Flat Phantom - ELI

The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (Oval Flat) phantom defined in IEEE 1528-2013, CENELEC 50361 and IEC 62209-2. It enables the dosimetric evaluation of wireless portable device 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 manually teaching three points with the robot.

|                               |                        |
|-------------------------------|------------------------|
| Shell Thickness               | 2 ±0.2 mm              |
| Filling Volume                | Approx. 30 liters      |
| Dimensions                    | 190×600×400 mm (H×L×W) |
| Table 1. Specification of ELI |                        |



## 6. Tissue Simulating Liquids

### IEEE SCC-34/SC-2 in 1528 recommended Tissue Dielectric Parameters

The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in 1528 have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in human head. Other head and body tissue parameters that have not been specified in 1528 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equation and extrapolated according to the head parameter specified in 1528.

| Target Frequency<br>(MHz)  | Head         |                | Body         |                |
|--|--------------|----------------|--------------|----------------|
|  | $\epsilon_r$ | $\sigma$ (S/m) | $\epsilon_r$ | $\sigma$ (S/m) |
| 150  | 52.3         | 0.76           | 61.9         | 0.80           |
| 300  | 45.3         | 0.87           | 58.2         | 0.92           |
| 450  | 43.5         | 0.87           | 56.7         | 0.94           |
| 835  | 41.5         | 0.90           | 55.2         | 0.97           |
| 900  | 41.5         | 0.97           | 55.0         | 1.05           |
| 915  | 41.5         | 0.98           | 55.0         | 1.06           |
| 1450   | 40.5         | 1.20           | 54.0         | 1.30           |
| 1610   | 40.3         | 1.29           | 53.8         | 1.40           |
| 1800 - 2000  | 40.0         | 1.40           | 53.3         | 1.52           |
| 2450   | 39.2         | 1.80           | 52.7         | 1.95           |
| 3000   | 38.5         | 2.40           | 52.0         | 2.73           |
| 5800   | 35.3         | 5.27           | 48.2         | 6.00           |
| ( $\epsilon_r$ = relative permittivity, $\sigma$ = conductivity and $\rho = 1000 \text{ kg/m}^3$ ) |              |                |              |                |

Table 2. Tissue dielectric parameters for head and body phantoms

## 6.1 The composition of the tissue simulating liquid

| Ingredients<br>(% by weight)        | Frequency (MHz) |       |       |       |       |       |       |       |       |       |       |       | Frequency<br>(GHz) |               |
|-------------------------------------|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------|---------------|
|                                     | 750             |       | 835   |       | 1750  |       | 1900  |       | 2450  |       | 2600  |       | 5 GHz              |               |
| Tissue Type                         | Head            | Body  | Head  | Body  | Head  | Body  | Head  | Body  | Head  | Body  | Head  | Body  | Head               | Body          |
| Water                               | 39.28           | 51.30 | 41.45 | 52.40 | 54.50 | 40.20 | 54.90 | 40.40 | 62.70 | 73.20 | 60.30 | 71.40 | 65.5               | 78.6          |
| Salt (NaCl)                         | 1.47            | 1.42  | 1.45  | 1.50  | 0.17  | 0.49  | 0.18  | 0.50  | 0.50  | 0.10  | 0.60  | 0.20  | 0.00               | 0.00          |
| Sugar                               | 58.15           | 46.18 | 56.00 | 45.00 | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00               | 0.00          |
| HEC                                 | 1.00            | 1.00  | 1.00  | 1.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00               | 0.00          |
| Bactericide                         | 0.10            | 0.10  | 0.10  | 0.10  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00               | 0.00          |
| Triton X-100                        | 0.00            | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 17.2               | 10.7          |
| DGBE                                | 0.00            | 0.00  | 0.00  | 0.00  | 45.33 | 59.31 | 44.92 | 59.10 | 36.80 | 26.70 | 39.10 | 28.40 | 0.00               | 0.00          |
| Diethylene Glycol<br>Mono-hexlether | 0.00            | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 17.3               | 10.7          |
| Dielectric<br>Constant              | 41.88           | 54.60 | 42.54 | 56.10 | 40.10 | 53.60 | 39.90 | 54.00 | 39.80 | 52.50 | 39.80 | 52.50 | 35.1~<br>36.2      | 47.9~<br>49.3 |
| Conductivity<br>(S/m)               | 0.90            | 0.97  | 0.91  | 0.95  | 1.39  | 1.49  | 1.42  | 1.45  | 1.88  | 1.78  | 1.88  | 1.78  | 4.45~<br>5.48      | 5.07~<br>6.23 |

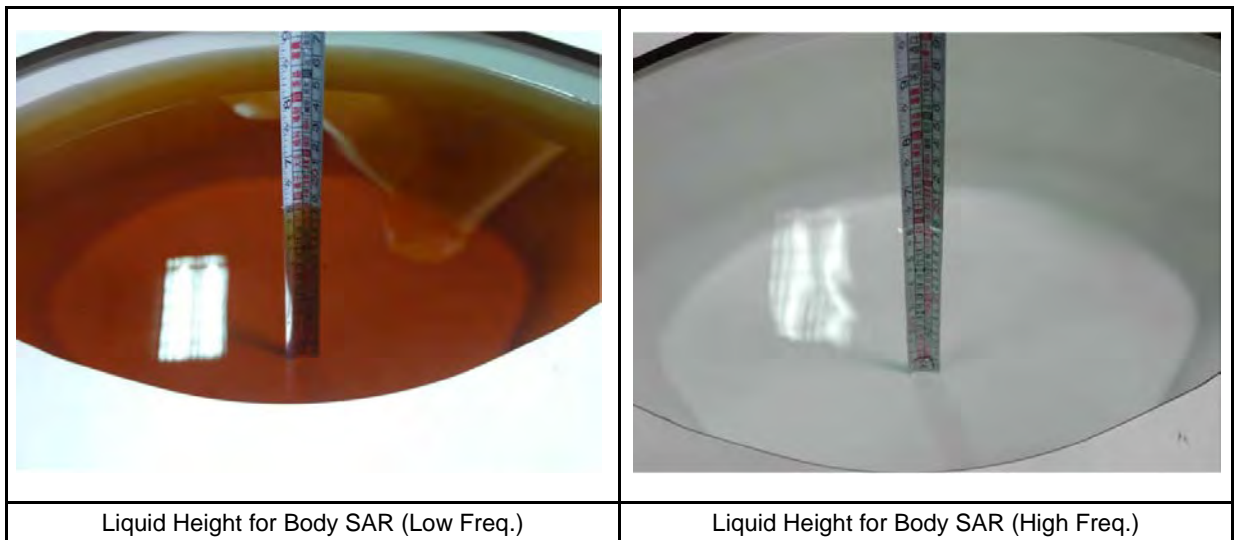
## 6.2 Liquid Parameters

1. The dielectric parameters of the liquids were verified prior to the SAR evaluation using an DAKS 3.5 Probe Kit.
2. The SAR testing with IEC tissue parameters as an alternative option to Head and body parameters. We used head TSL for body SAR tests. There are some limitations though:
  - (a) The mixing and matching of head TSL and body TSL for body SAR testing in a single application are not permitted. For example, we cannot start testing body SAR with head TSL and then switch to testing Body SAR with Body TSL.
  - (b) The TSL used for body SAR testing can be changed via a Permissive Change. However, if the body SAR increases and the original Body SAR was > 1.2 W/kg, additional SAR measurements may be required.

| Tissue Temp (°C) | Liquid Type | Frequency (MHz) | Cond.    | Perm.        | target Cond. | target Perm. | $\sigma$ (Delta) (%) | $\epsilon_r$ (Delta) (%) | Limit (%) | Date          |
|------------------|-------------|-----------------|----------|--------------|--------------|--------------|----------------------|--------------------------|-----------|---------------|
|                  |             |                 | $\sigma$ | $\epsilon_r$ | $\sigma$     | $\epsilon_r$ |                      |                          |           |               |
| 22.1             | Head        | 5180 MHz        | 4.56     | 37.229       | 4.64         | 36.02        | -1.63                | 3.36                     | ±5        | Sep. 29, 2020 |
| 22.1             | Head        | 5190 MHz        | 4.58     | 37.195       | 4.65         | 36.01        | -1.60                | 3.29                     | ±5        | Sep. 29, 2020 |
| 22.1             | Head        | 5200 MHz        | 4.59     | 37.142       | 4.66         | 36.00        | -1.49                | 3.17                     | ±5        | Sep. 29, 2020 |
| 22.1             | Head        | 5220 MHz        | 4.62     | 37.083       | 4.68         | 35.98        | -1.20                | 3.06                     | ±5        | Sep. 29, 2020 |
| 22.1             | Head        | 5230 MHz        | 4.64     | 37.059       | 4.69         | 35.97        | -1.04                | 3.03                     | ±5        | Sep. 29, 2020 |
| 22.1             | Head        | 5240 MHz        | 4.65     | 37.031       | 4.70         | 35.96        | -1.09                | 2.98                     | ±5        | Sep. 29, 2020 |
| 22.1             | Head        | 5250 MHz        | 4.66     | 37.026       | 4.71         | 35.95        | -1.10                | 2.99                     | ±5        | Sep. 29, 2020 |
| 22.1             | Head        | 5745 MHz        | 5.29     | 35.984       | 5.22         | 35.36        | 1.35                 | 1.76                     | ±5        | Sep. 29, 2020 |
| 22.1             | Head        | 5755 MHz        | 5.27     | 36.028       | 5.23         | 35.35        | 0.91                 | 1.92                     | ±5        | Sep. 29, 2020 |
| 22.1             | Head        | 5775 MHz        | 5.24     | 36.070       | 5.25         | 35.33        | -0.06                | 2.09                     | ±5        | Sep. 29, 2020 |
| 22.1             | Head        | 5785 MHz        | 5.23     | 36.061       | 5.26         | 35.32        | -0.40                | 2.10                     | ±5        | Sep. 29, 2020 |
| 22.1             | Head        | 5795 MHz        | 5.23     | 36.063       | 5.27         | 35.31        | -0.61                | 2.13                     | ±5        | Sep. 29, 2020 |
| 22.1             | Head        | 5825 MHz        | 5.24     | 35.939       | 5.30         | 35.28        | -1.04                | 1.87                     | ±5        | Sep. 29, 2020 |
| 22.6             | Head        | 2412 MHz        | 1.81     | 39.617       | 1.77         | 39.27        | 2.47                 | 0.88                     | ±5        | Oct. 04, 2020 |
| 22.6             | Head        | 2422 MHz        | 1.82     | 39.577       | 1.78         | 39.25        | 2.57                 | 0.83                     | ±5        | Oct. 04, 2020 |
| 22.6             | Head        | 2437 MHz        | 1.84     | 39.529       | 1.79         | 39.22        | 2.74                 | 0.79                     | ±5        | Oct. 04, 2020 |
| 22.6             | Head        | 2452 MHz        | 1.85     | 39.484       | 1.80         | 39.20        | 2.79                 | 0.72                     | ±5        | Oct. 04, 2020 |
| 22.6             | Head        | 2462 MHz        | 1.86     | 39.444       | 1.81         | 39.18        | 2.73                 | 0.67                     | ±5        | Oct. 04, 2020 |
| 22.6             | Head        | 2467 MHz        | 1.87     | 39.425       | 1.82         | 39.18        | 2.75                 | 0.63                     | ±5        | Oct. 04, 2020 |
| 22.6             | Head        | 2472 MHz        | 1.87     | 39.409       | 1.82         | 39.17        | 2.76                 | 0.61                     | ±5        | Oct. 04, 2020 |

### 6.3 Liquid Depth

According to KDB865664, the depth of tissue-equivalent liquid in a phantom must be  $\geq 15.0$  cm. Which is shown in Figure 7 & 8.



## 7. SAR Testing with RF Transmitters

### 7.1 SAR Testing with WLAN

SAR test reduction for 802.11 Wi-Fi transmission mode configurations are considered separately for DSSS and OFDM. An initial test position is determined to reduce the number of tests required for certain exposure configurations with multiple test positions. An initial test configuration is determined for each frequency band and aggregated band according to maximum output power, channel bandwidth, wireless mode configurations and other operating parameters to streamline the measurement requirements. For 2.4 GHz DSSS, either the initial test position or DSSS procedure is applied to reduce the number of SAR tests; these are mutually exclusive. For OFDM, an initial test position is only applicable to next to the ear, UMPC mini-tablet and hotspot mode configurations, which is tested using the initial test configuration to facilitate test reduction. For other exposure conditions with a fixed test position, SAR test reduction is determined using only the initial test configuration.

The multiple test positions require SAR measurements in head, hotspot mode or UMPC mini-tablet configurations may be reduced according to the highest reported SAR determined using the initial test position(s) by applying the DSSS or OFDM SAR measurement procedures in the required wireless mode test configuration(s). The initial test position(s) is measured using the highest measured maximum output power channel in the required wireless mode test configuration(s). When the reported SAR for the initial test position is:

- $\leq 0.4$  W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and wireless mode combination within the frequency band or aggregated band. DSSS and OFDM configurations are considered separately according to the required SAR procedures.
- $> 0.4$  W/kg, SAR is repeated using the same wireless mode test configuration tested in the initial test position to measure the subsequent next closest/smallest test separation distance and maximum coupling test position, on the highest maximum output power channel, until the reported SAR is  $\leq 0.8$  W/kg or all required test positions are tested.
  - For subsequent test positions with equivalent test separation distance or when exposure is dominated by coupling conditions, the position for maximum coupling condition should be tested.
  - When it is unclear, all equivalent conditions must be tested.
- For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is  $> 0.8$  W/kg, measure the SAR for these positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is  $\leq 1.2$  W/kg or all required test channels are considered.
  - The additional power measurements required for this step should be limited to those necessary for identifying subsequent highest output power channels to apply the test reduction.
- When the specified maximum output power is the same for both UNII 1 and UNII 2A, begin SAR measurements in UNII 2A with the channel with the highest measured output power. If the reported SAR for UNII 2A is  $\leq 1.2$  W/kg, SAR is not required for UNII 1; otherwise treat the remaining bands separately and test them independently for SAR.
- When the specified maximum output power is different between UNII 1 and UNII 2A, begin SAR with the band that has the higher specified maximum output. If the highest reported SAR for the band with the highest specified power is  $\leq 1.2$  W/kg, testing for the band with the lower specified output power is not required; otherwise test the remaining bands independently for SAR.

To determine the initial test position, Area Scans were performed to determine the position with the Maximum Value of SAR (measured). The position that produced the highest Maximum Value of SAR is considered the worst case position; thus used as the initial test position.



## 7.2 Conducted Power Measurements

| §15.247 (2.4 GHz) |         |                 |                     |               |                     |               |
|-------------------|---------|-----------------|---------------------|---------------|---------------------|---------------|
| Mode              | Channel | Frequency (MHz) | MAIN                |               | AUX                 |               |
|                   |         |                 | Average power (dBm) | Tune-Up Limit | Average power (dBm) | Tune-Up Limit |
| 802.11b 1Mbps     | 1       | 2412            | 17.02               | 18.00         | ---                 | ---           |
|                   | 6       | 2437            | 17.21               | 18.00         | ---                 | ---           |
|                   | 11      | 2462            | 16.80               | 18.00         | ---                 | ---           |
| 802.11g 6Mbps     | 1       | 2412            | 16.72               | 17.00         | ---                 | ---           |
|                   | 6       | 2437            | 18.94               | 19.00         | ---                 | ---           |
|                   | 11      | 2462            | 16.51               | 17.00         | ---                 | ---           |
| 802.11n-HT20 MCS0 | 1       | 2412            | 13.04               | 14.00         | 14.44               | 15.00         |
|                   | 6       | 2437            | 16.72               | 17.00         | 18.54               | 19.00         |
|                   | 11      | 2462            | 12.72               | 13.00         | 14.32               | 15.00         |
| 802.11n-HT40 MCS0 | 1       | 2412            | 12.75               | 13.00         | 14.14               | 15.00         |
|                   | 6       | 2437            | 13.22               | 14.00         | 14.64               | 15.00         |
|                   | 11      | 2462            | 12.04               | 13.00         | 13.62               | 14.00         |

- As per FCC OET KDB 248227 D01, conducted output power and SAR testing are not required for 802.11g/n20/n40/ax channels when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is  $\leq 1.2\text{W/kg}$ .
- When the reported SAR of the initial test configuration is  $> 0.8\text{ W/kg}$ , SAR measurement is required for subsequent next highest measured output power channel(s) in the initial test configuration until reported SAR is  $\leq 1.2\text{ W/kg}$  or all required channels are tested.

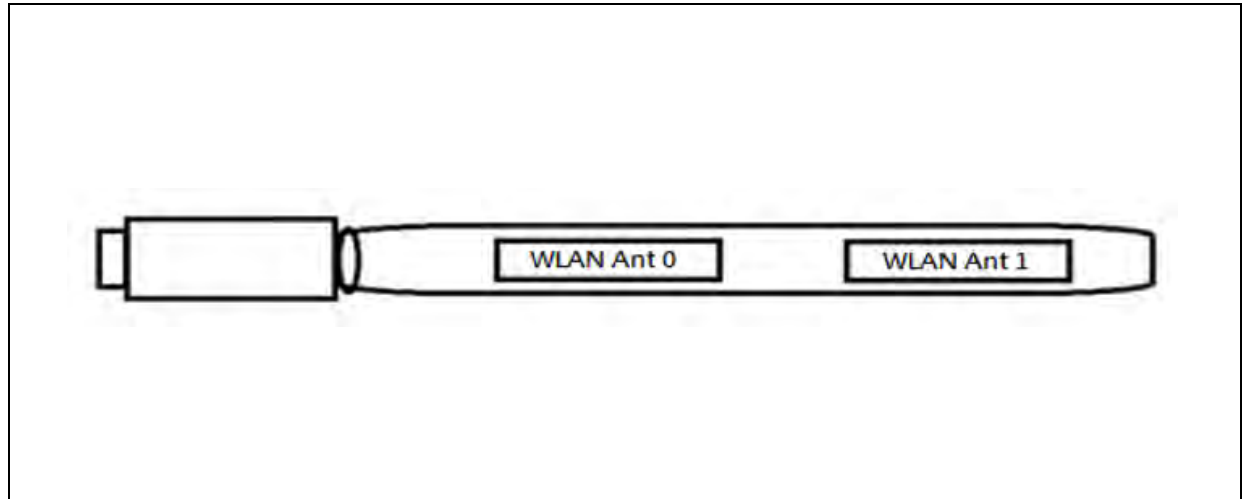


| U-NII-1             |         |                    |                        |                  |                        |                  |
|---------------------|---------|--------------------|------------------------|------------------|------------------------|------------------|
| Mode                | Channel | Frequency<br>(MHz) | MAIN                   |                  | AUX                    |                  |
|                     |         |                    | Average power<br>(dBm) | Tune-Up<br>Limit | Average power<br>(dBm) | Tune-Up<br>Limit |
| 802.11a 6Mbps       | 36      | 5180               | 10.18                  | 10.50            | ---                    | ---              |
|                     | 40      | 5200               | 10.07                  | 10.50            | ---                    | ---              |
|                     | 44      | 5220               | 10.02                  | 10.50            | ---                    | ---              |
|                     | 48      | 5240               | 10.12                  | 10.50            | ---                    | ---              |
| 802.11n-HT20 MCS0   | 36      | 5180               | 10.02                  | 10.50            | 14.45                  | 15.00            |
|                     | 40      | 5200               | 10.15                  | 10.50            | 14.32                  | 15.00            |
|                     | 44      | 5220               | 9.93                   | 10.50            | 14.17                  | 15.00            |
|                     | 48      | 5240               | 9.86                   | 10.50            | 14.13                  | 15.00            |
| 802.11n-HT40 MCS0   | 38      | 5190               | 10.20                  | 10.50            | 14.26                  | 15.00            |
|                     | 46      | 5230               | 9.98                   | 10.50            | 14.49                  | 15.00            |
| 802.11ac-VHT20 MCS0 | 36      | 5180               | 10.04                  | 10.50            | 14.54                  | 15.00            |
|                     | 40      | 5200               | 10.17                  | 10.50            | 14.34                  | 15.00            |
|                     | 44      | 5220               | 10.05                  | 10.50            | 14.28                  | 15.00            |
|                     | 48      | 5240               | 9.92                   | 10.50            | 14.23                  | 15.00            |
| 802.11ac-VHT40 MCS0 | 38      | 5190               | 10.27                  | 10.50            | 14.31                  | 15.00            |
|                     | 46      | 5230               | 10.09                  | 10.50            | 14.62                  | 15.00            |
| 802.11ac-VHT80 MCS0 | 42      | 5210               | 10.31                  | 10.50            | 13.91                  | 14.50            |

| U-NII-3/§15.247 (5.8 GHz) |         |                 |                     |               |                     |               |
|---------------------------|---------|-----------------|---------------------|---------------|---------------------|---------------|
| Mode                      | Channel | Frequency (MHz) | MAIN                |               | AUX                 |               |
|                           |         |                 | Average power (dBm) | Tune-Up Limit | Average power (dBm) | Tune-Up Limit |
| 802.11a MCS0              | 149     | 5745            | 10.08               | 11.00         | ---                 | ---           |
|                           | 157     | 5785            | 10.06               | 11.00         | ---                 | ---           |
|                           | 165     | 5825            | 10.03               | 11.00         | ---                 | ---           |
| 802.11n-HT20 MCS0         | 149     | 5745            | 10.03               | 11.00         | 9.38                | 10.50         |
|                           | 157     | 5785            | 9.82                | 11.00         | 9.29                | 10.50         |
|                           | 165     | 5825            | 10.16               | 11.00         | 9.22                | 10.50         |
| 802.11n-HT40 MCS0         | 151     | 5755            | 10.03               | 11.00         | 9.42                | 10.50         |
|                           | 159     | 5795            | 9.93                | 11.00         | 9.26                | 10.50         |
| 802.11ac-VHT20 MCS0       | 149     | 5745            | 10.13               | 11.00         | 9.47                | 10.50         |
|                           | 157     | 5785            | 9.86                | 11.00         | 9.34                | 10.50         |
|                           | 165     | 5825            | 10.26               | 11.00         | 9.28                | 10.50         |
| 802.11ac-VHT40 MCS0       | 151     | 5755            | 10.07               | 11.00         | 9.48                | 10.50         |
|                           | 159     | 5795            | 10.01               | 11.00         | 9.37                | 10.50         |
| 802.11ac-VHT80 MCS0       | 155     | 5775            | 10.47               | 11.00         | 9.88                | 10.50         |

1. Additional conducted power measurement is required when reported SAR is  $> 1.2\text{W/kg}$ . In case the subsequent test configuration and the channel bandwidth is smaller than the initial test configuration, all channels that overlap with the larger channel bandwidth in the initial configuration should be tested.
2. The initial test configuration for 2.4 GHz and 5 GHz OFDM transmission modes is determined by the 802.11 configuration with the highest maximum output power specified for production units, including tune-up tolerance, in each standalone and aggregated frequency band. SAR for the initial test configuration is measured using the highest maximum output power channel determined by the default power measurement procedures. When multiple transmission modes (802.11a/g/n/ac/ax) have the same specified maximum output power, largest channel bandwidth, lowest order modulation and lowest data rate, lowest order 802.11 mode is selected (i.e. a, g, n, ac then ax)
3. When the highest reported SAR for the initial test configuration (when applicable, include subsequent highest output channels), according to the initial test position or fixed exposure requirements, is adjusted by the ratio of the subsequent test configuration to the initial test configuration specified maximum output power and the adjusted SAR is  $\leq 1.2\text{ W/Kg}$ , SAR is not required for that subsequent test configuration.

### 7.3 Antenna location



### 7.4 Simultaneous Transmitting Evaluate

Simultaneous transmission configurations as below:

| Condition | Band                  |                      |                     |                    |
|-----------|-----------------------|----------------------|---------------------|--------------------|
|           | 2.4 GHz WLAN Ant Main | 2.4 GHz WLAN Ant Aux | 5 GHz WLAN Ant Main | 5 GHz WLAN Ant Aux |
| 1         | V                     | V                    | ---                 | ---                |
| 2         | V                     | ---                  | ---                 | V                  |
| 3         | ---                   | V                    | V                   | ---                |
| 4         | ---                   | ---                  | V                   | V                  |

#### 7.4.1 Sum of 1-g SAR of all simultaneously transmitting

1. When the sum of 1-g SAR of all simultaneously transmitting antennas in an operating mode and exposure condition combination is within the SAR limit, SAR test exclusion applies to that simultaneous transmission configuration.
2. Sum of 1-g SAR of simultaneously transmitting portable device exposure condition combination is within the SAR limit of 1.6W/kg.

## 8.1 Symmetric Dipoles for System Verification

Return Loss > 20 dB at specified verification position

Figure 1. System Verification Setup Diagram

Figure 2. Validation Kit

Figure 1. System Verification Setup Diagram



Figure 2. Validation Kit

## 8.2 Verification Summary

Prior to the assessment, the system validation kit was used to test whether the system was operating within its specifications of  $\pm 10\%$ . The measured SAR will be normalized to 1 W input power. The verification was performed at 2450, 5250, 5600 and 5750 MHz.

| Mixture Type | Frequency (MHz) | Power  | Probe              | Dipole             | SAR <sub>1g</sub> (W/Kg) | Normalize to 1 Watt 1 g (W/Kg) | 1 W Target SAR <sub>1g</sub> (W/Kg) | SAR <sub>10g</sub> (W/Kg) | Normalize to 1 Watt 10 g (W/Kg) | 1 W Target SAR <sub>10g</sub> (W/Kg) | Difference percentage 1 g | Difference percentage 10 g | Date          |
|--------------|-----------------|--------|--------------------|--------------------|--------------------------|--------------------------------|-------------------------------------|---------------------------|---------------------------------|--------------------------------------|---------------------------|----------------------------|---------------|
|              |                 |        | Model / Serial No. | Model / Serial No. |                          |                                |                                     |                           |                                 |                                      |                           |                            |               |
| Head         | 2450            | 250 mW | EX3DV4-S N3847     | D2450V2 – SN712    | 13.4                     | 53.6                           | 51.20                               | 6.36                      | 25.44                           | 23.60                                | 4.5%                      | 7.2%                       | Oct. 04, 2020 |
| Head         | 5250            | 100 mW | EX3DV4-S N3847     | D5250V2 – SN1021   | 7.7                      | 77                             | 75.50                               | 2.16                      | 21.6                            | 21.40                                | 1.9%                      | 0.9%                       | Sep. 29, 2020 |
| Head         | 5750            | 100 mW | EX3DV4-S N3847     | D5750V2 – SN1021   | 8                        | 80                             | 76.00                               | 2.19                      | 21.9                            | 21.30                                | 5.0%                      | 2.7%                       | Sep. 29, 2020 |

## 9. Test Equipment List

Testing Engineer: Jason Tsao

| Manufacturer  | Name of Equipment             | Type/Model                 | Serial Number   | Calibration |            |
|---------------|-------------------------------|----------------------------|-----------------|-------------|------------|
|               |                               |                            |                 | Cal. Date   | Cal.Period |
| SPEAG         | 2450MHz System Validation Kit | D2450V2                    | 712             | 2020/04/26  | 1 year     |
| SPEAG         | 5GHz System Validation Kit    | D5GHzV2                    | 1021            | 2020/04/23  | 1 year     |
| SPEAG         | Dosimetric E-Field Probe      | EX3DV4                     | 3847            | 2020/05/20  | 1 year     |
| SPEAG         | Data Acquisition Electronics  | DAE4                       | 541             | 2020/03/18  | 1 year     |
| SPEAG         | Measurement Server            | SE UMS 011 AA              | 1025            | NCR         |            |
| SPEAG         | Device Holder                 | N/A                        | N/A             | NCR         |            |
| SPEAG         | Phantom                       | ELI V4.0                   | 1036            | NCR         |            |
| SPEAG         | Robot                         | Staubli TX90XL             | F16/54FTA1/A/01 | NCR         |            |
| SPEAG         | Software                      | DASY52<br>V52.10 (3)       | N/A             | NCR         |            |
| SPEAG         | Software                      | SEMCAD X<br>V14.6.10(7331) | N/A             | NCR         |            |
| SPEAG         | Network Analyzer              | DAKS_VNA R140              | 0010318         | 2020/05/26  | 1 year     |
| SPEAG         | Dielectric Probe Kit          | DAKS-3.5                   | 1101            | 2020/05/26  | 1 year     |
| HILA          | Digital Thermometer           | TM-906A                    | 1500033         | 2019/10/28  | 1 year     |
| Agilent       | Power Sensor                  | 8481H                      | 3318A20779      | 2020/06/09  | 1 year     |
| Agilent       | Power Meter                   | EDM Series E4418B          | GB40206143      | 2020/06/09  | 1 year     |
| Agilent       | Signal Generator              | E8257D                     | MY44320425      | 2020/03/04  | 1 year     |
| Agilent       | Dual Directional Coupler      | 778D                       | 50334           | NCR         |            |
| Woken         | Dual Directional Coupler      | 0100AZ20200801O            | 11012409517     | NCR         |            |
| Mini-Circuits | Power Amplifier               | EMC014225P                 | 980292          | NCR         |            |
| Mini-Circuits | Power Amplifier               | EMC2830P                   | 980293          | NCR         |            |
| Aisi          | Attenuator                    | IEAT 3dB                   | N/A             | NCR         |            |

Table 1. Test Equipment List

## 10. Measurement Uncertainty

Decision Rule

■ Uncertainty is not included.

□ Uncertainty is included.

| IEC 62209-2<br>Measurement uncertainty evaluation template for handset SAR test (300 MHz~3 GHz) |      |             |       |                     |                      |                              |                               |                |
|---|------|-------------|-------|---------------------|----------------------|------------------------------|-------------------------------|----------------|
| Uncertainty component   | Tol. | Prob. Dist. | Div.  | C <sub>i</sub> - 1g | C <sub>i</sub> - 10g | u <sub>i</sub> - 1g<br>(± %) | u <sub>i</sub> - 10g<br>(± %) | v <sub>i</sub> |
| <b>Measurement system</b>   |      |             |       |                     |                      |                              |                               |                |
| Probe calibration   | 6.1  | N           | 1     | 1                   | 1                    | 6.1                          | 6.1                           | ∞              |
| Axial isotropy  | 4.7  | R           | 1.732 | 0.7                 | 0.7                  | 1.9                          | 1.9                           | ∞              |
| Hemispherical isotropy  | 9.6  | R           | 1.732 | 0.7                 | 0.7                  | 3.9                          | 3.9                           | ∞              |
| Boundary effect   | 1.0  | R           | 1.732 | 1                   | 1                    | 0.6                          | 0.6                           | ∞              |
| Linearity   | 4.7  | R           | 1.732 | 1                   | 1                    | 2.7                          | 2.7                           | ∞              |
| System detection limits   | 0.25 | R           | 1.732 | 1                   | 1                    | 0.1                          | 0.1                           | ∞              |
| Readout electronics   | 0.3  | N           | 1     | 1                   | 1                    | 0.3                          | 0.3                           | ∞              |
| Response time   | 0.0  | R           | 1.732 | 1                   | 1                    | 0.0                          | 0.0                           | ∞              |
| Integration time  | 2.6  | R           | 1.732 | 1                   | 1                    | 1.5                          | 1.5                           | ∞              |
| RF Ambient Noise  | 3.0  | R           | 1.732 | 1                   | 1                    | 1.7                          | 1.7                           | ∞              |
| RF Ambient Reflections  | 3.0  | R           | 1.732 | 1                   | 1                    | 1.7                          | 1.7                           | ∞              |
| Probe Positioner  | 0.02 | R           | 1.732 | 1                   | 1                    | 0.01                         | 0.01                          | ∞              |
| Probe Positioning   | 0.4  | R           | 1.732 | 1                   | 1                    | 0.2                          | 0.2                           | ∞              |
| Max. SAR evaluation   | 2.0  | R           | 1.732 | 1                   | 1                    | 1.2                          | 1.2                           | ∞              |
| <b>Test sample related</b>  |      |             |       |                     |                      |                              |                               |                |
| Test sample positioning   | 2.9  | N           | 1     | 1                   | 1                    | 2.9                          | 2.9                           | 145            |
| Device holder uncertainty   | 3.6  | N           | 1     | 1                   | 1                    | 3.6                          | 3.6                           | 7              |
| SAR drift measurement   | 5.0  | R           | 1.732 | 1                   | 1                    | 2.9                          | 2.9                           | ∞              |
| <b>Phantom and tissue parameters</b>  |      |             |       |                     |                      |                              |                               |                |
| Phantom shell uncertainty   | 7.2  | R           | 1.732 | 1                   | 1                    | 4.2                          | 4.2                           | ∞              |
| Liquid Conductivity (target)  | 5.0  | R           | 1.732 | 0.78                | 0.71                 | 2.3                          | 2.0                           | ∞              |
| Liquid Conductivity (measurement)   | 4.8  | R           | 1.732 | 0.78                | 0.71                 | 2.2                          | 2.0                           | ∞              |
| Liquid Permittivity (target)  | 5.0  | R           | 1.732 | 0.23                | 0.26                 | 0.7                          | 0.8                           | ∞              |
| Liquid Permittivity (measurement)   | 4.8  | R           | 1.732 | 0.23                | 0.26                 | 0.6                          | 0.7                           | ∞              |
| <b>Combined standard uncertainty</b>  |      |             |       |                     |                      |                              |                               |                |
| -   | -    | RSS         | -     | -                   | -                    | 11.4                         | 11.4                          | 693            |
| <b>Expanded uncertainty (95% confidence interval)</b>   |      |             |       |                     |                      |                              |                               |                |
| -   | -    | k =2        | -     | -                   | -                    | 22.9                         | 22.7                          | -              |

Uncertainty Budget for frequency range 300 MHz to 3 GHz



| IEC 62209-2<br>Measurement uncertainty evaluation template for handset SAR test (3 GHz~6 GHz) |      |             |       |                     |                      |                              |                               |                |
|---|------|-------------|-------|---------------------|----------------------|------------------------------|-------------------------------|----------------|
| Uncertainty component   | Tol. | Prob. Dist. | Div.  | C <sub>i</sub> - 1g | C <sub>i</sub> - 10g | u <sub>i</sub> - 1g<br>(± %) | u <sub>i</sub> - 10g<br>(± %) | v <sub>i</sub> |
| <b>Measurement system</b>   |      |             |       |                     |                      |                              |                               |                |
| Probe calibration   | 6.1  | N           | 1     | 1                   | 1                    | 6.1                          | 6.1                           | ∞              |
| Axial isotropy  | 4.7  | R           | 1.732 | 0.7                 | 0.7                  | 1.9                          | 1.9                           | ∞              |
| Hemispherical isotropy  | 9.6  | R           | 1.732 | 0.7                 | 0.7                  | 3.9                          | 3.9                           | ∞              |
| Boundary effect   | 1.0  | R           | 1.732 | 1                   | 1                    | 0.6                          | 0.6                           | ∞              |
| Linearity   | 4.7  | R           | 1.732 | 1                   | 1                    | 2.7                          | 2.7                           | ∞              |
| System detection limits   | 0.25 | R           | 1.732 | 1                   | 1                    | 0.1                          | 0.1                           | ∞              |
| Readout electronics   | 0.3  | N           | 1     | 1                   | 1                    | 0.3                          | 0.3                           | ∞              |
| Response time   | 0.0  | R           | 1.732 | 1                   | 1                    | 0.0                          | 0.0                           | ∞              |
| Integration time  | 2.6  | R           | 1.732 | 1                   | 1                    | 1.5                          | 1.5                           | ∞              |
| RF Ambient Noise  | 3.0  | R           | 1.732 | 1                   | 1                    | 1.7                          | 1.7                           | ∞              |
| RF Ambient Reflections  | 3.0  | R           | 1.732 | 1                   | 1                    | 1.7                          | 1.7                           | ∞              |
| Probe Positioner  | 0.02 | R           | 1.732 | 1                   | 1                    | 0.01                         | 0.01                          | ∞              |
| Probe Positioning   | 0.4  | R           | 1.732 | 1                   | 1                    | 0.2                          | 0.2                           | ∞              |
| Max. SAR evaluation   | 2.0  | R           | 1.732 | 1                   | 1                    | 1.2                          | 1.2                           | ∞              |
| <b>Test sample related</b>  |      |             |       |                     |                      |                              |                               |                |
| Test sample positioning   | 2.9  | N           | 1     | 1                   | 1                    | 2.9                          | 2.9                           | 145            |
| Device holder uncertainty   | 3.6  | N           | 1     | 1                   | 1                    | 3.6                          | 3.6                           | 7              |
| SAR drift measurement   | 5.0  | R           | 1.732 | 1                   | 1                    | 2.9                          | 2.9                           | ∞              |
| <b>Phantom and tissue parameters</b>  |      |             |       |                     |                      |                              |                               |                |
| Phantom shell uncertainty   | 7.6  | R           | 1.732 | 1                   | 1                    | 4.4                          | 4.4                           | ∞              |
| Liquid Conductivity (target)  | 5.0  | R           | 1.732 | 0.78                | 0.71                 | 2.3                          | 2.0                           | ∞              |
| Liquid Conductivity (measurement)   | 4.8  | R           | 1.732 | 0.78                | 0.71                 | 2.2                          | 2.0                           | ∞              |
| Liquid Permittivity (target)  | 5.0  | R           | 1.732 | 0.23                | 0.26                 | 0.7                          | 0.8                           | ∞              |
| Liquid Permittivity (measurement)   | 4.8  | R           | 1.732 | 0.23                | 0.26                 | 0.6                          | 0.7                           | ∞              |
| <b>Combined standard uncertainty</b>  |      |             |       |                     |                      |                              |                               |                |
| -   | -    | RSS         | -     | -                   | -                    | 12.1                         | 12.0                          | 859            |
| <b>Expanded uncertainty (95% confidence interval)</b>   |      |             |       |                     |                      |                              |                               |                |
| -   | -    | k =2        | -     | -                   | -                    | 24.1                         | 24.0                          | -              |

Uncertainty Budget for frequency range 3 GHz to 6 GHz

## 11. **Measurement Procedure**

The measurement procedures are as follows:

1. For WLAN function, engineering testing software installed on DUTs can provide continuous transmitting signal.
2. Measure output power through RF cable and power meter
3. Set scan area, grid size and other setting on the DASY software
4. Find out the largest SAR result on these testing positions of each band
5. Measure SAR results for other channels in worst SAR testing position if the SAR of highest power channel is larger than 0.8 W/kg

According to the test standard, the recommended procedure for assessing the peak spatial-average SAR value consists of the following steps:

1. Power reference measurement
2. Area scan
3. Zoom scan
4. Power drift measurement

### 11.1 **Spatial Peak SAR Evaluation**

The procedure for spatial peak SAR evaluation has been implemented according to the test standard. It can be conducted for 1 g and 10 g, as well as for user-specific masses. The DASY software includes all numerical procedures necessary to evaluate the spatial peak SAR value.

The base for the evaluation is a "cube" measurement. The measured volume must include the 1 g and 10 g cubes with the highest averaged SAR values. For that purpose, the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan.

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. Extraction of the measured data (grid and values) from the Zoom Scan
2. Calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
3. Generation of a high-resolution mesh within the measured volume
4. Interpolation of all measured values from the measurement grid to the high-resolution grid
5. Extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
6. Calculation of the averaged SAR within masses of 1 g and 10 g

## 11.2 Area & Zoom Scan Procedures

First Area Scan is used to locate the approximate location(s) of the local peak SAR value(s). The measurement grid within an Area Scan is defined by the grid extent, grid step size and grid offset. Next, in order to determine the EM field distribution in a three-dimensional spatial extension, Zoom Scan is required. The Zoom Scan measures points and step size follow as below. The Zoom Scan is performed around the highest E-field value to determine the averaged SAR-distribution over 10 g.

|   |                                    |  | $\leq 3$ GHz   | $> 3$ GHz   |
|---|------------------------------------|--|--|---|
| Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface  |                                    |  | 5 mm $\pm$ 1 mm  | $\frac{1}{2} \cdot \delta \cdot \ln(2)$ mm $\pm$ 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: $\Delta x_{Area}$ , $\Delta y_{Area}$   |                                    |  | $\leq 2$ GHz: $\leq 15$ mm<br>2 – 3 GHz: $\leq 12$ mm  | 3 – 4 GHz: $\leq 12$ mm<br>4 – 6 GHz: $\leq 10$ 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: $\Delta x_{Zoom}$ , $\Delta y_{Zoom}$   |                                    |  | $\leq 2$ GHz: $\leq 8$ mm<br>2 – 3 GHz: $\leq 5$ mm*   | 3 – 4 GHz: $\leq 5$ mm*<br>4 – 6 GHz: $\leq 4$ mm*                            |
| Maximum zoom scan spatial resolution, normal to phantom surface   | uniform grid: $\Delta z_{Zoom}(n)$ |  | $\leq 5$ mm  | 3 – 4 GHz: $\leq 4$ mm<br>4 – 5 GHz: $\leq 3$ mm<br>5 – 6 GHz: $\leq 2$ mm    |
|   | graded grid                        | $\Delta z_{Zoom}(1)$ : between 1 <sup>st</sup> two points closest to phantom surface | $\leq 4$ mm  | 3 – 4 GHz: $\leq 3$ mm<br>4 – 5 GHz: $\leq 2.5$ mm<br>5 – 6 GHz: $\leq 2$ mm  |
|   |                                    | $\Delta z_{Zoom}(n>1)$ : between subsequent points                                   | $\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$ mm   |   |
| Minimum zoom scan volume  | x, y, z                            |  | $\geq 30$ mm   | 3 – 4 GHz: $\geq 28$ mm<br>4 – 5 GHz: $\geq 25$ mm<br>5 – 6 GHz: $\geq 22$ mm |
| Note: $\delta$ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see IEEE Std 1528-2013 for details.   |                                    |  |  |   |
| * When zoom scan is required and the <u>reported</u> SAR from the <i>area scan based 1-g SAR estimation</i> procedures of KDB Publication 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. |                                    |  |  |   |

(Our measure settings are refer KDB Publication 865664 D01v01r04)

### 11.3 Volume Scan Procedures

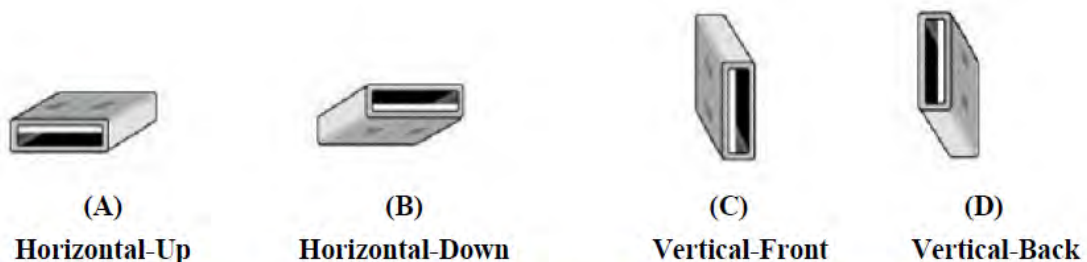
The volume scan is used for assess overlapping SAR distributions for antennas transmitting in different frequency bands. It is equivalent to an oversized zoom scan used in standalone measurements. The measurement volume will be used to enclose all the simultaneous transmitting antennas. For antennas transmitting simultaneously in different frequency bands, the volume scan is measured separately in each frequency band. In order to sum correctly to compute the 1 g aggregate SAR, the DUT remain in the same test position for all measurements and all volume scan use the same spatial resolution and grid spacing. When all volume scan were completed, the software, SEMCAD postprocessor can combine and subsequently superpose these measurement data to calculating the multiband SAR.

### 11.4 Power Drift Monitoring

All SAR testing is under the DUT install full charged battery and transmit maximum output power. In DASY measurement software, the power reference measurement and power drift measurement procedures are used for monitoring the power drift of DUT during SAR test. Both these procedures measure the field at a specified reference position before and after the SAR testing. The software will calculate the field difference in dB. If the power drifts more than 5 %, the SAR will be retested.

### 11.5 Simple Dongle Procedures

Test all USB orientations [see figure below: (A) Horizontal-Up, (B) Horizontal-Down, (C) Vertical-Front, and (D) Vertical-Back] with a device-to-phantom separation distance of 5 mm.



Note: These are USB connector orientations on laptop computers; USB dongles have the reverse configuration for plugging into the corresponding laptop computers.

**Figure 1 – USB Connector Orientations Implemented on Laptop Computers**

## 12. SAR Test Results Summary

Note:

1. According to KDB 248227 D01 Section 5.2.1, SAR is measured for 2.4 GHz 802.11b DSSS using either a fixed test position or, when applicable, the initial test position procedure. SAR test reduction is determined according to the following:
  - a. When the reported SAR of the highest measured maximum output power channel for the exposure configuration is  $\leq 0.8$  W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.
  - b. When the reported SAR is  $> 0.8$  W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is  $> 1.2$  W/kg, SAR is required for the third channel; i.e., all channels require testing.
2. According to KDB 248227 D01 Section 5.2.2, when SAR measurement is required for 2.4 GHz 802.11g/n OFDM configurations, the measurement and test reduction procedures for OFDM are applied. SAR is not required for the following 2.4 GHz OFDM conditions.
  - a. When KDB Publication 447498 D01 SAR test exclusion applies to the OFDM configuration.
  - b. When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is  $\leq 1.2$  W/kg.
3. According to KDB 248227 D01 Section 5.3.2, the initial test configuration for 2.4 GHz and 5 GHz OFDM transmission modes is determined by the 802.11 configuration with the highest maximum output power specified for production units, including tune-up tolerance, in each standalone and aggregated frequency band. SAR for the initial test configuration is measured using the highest maximum output power channel determined by the default power measurement procedures.
  - a. When multiple channel bandwidth configurations in a frequency band have the same specified maximum output power, the initial test configuration is determined by applying the following steps sequentially.
    - 1) The largest channel bandwidth configuration is selected among the multiple configurations in a frequency band with the same specified maximum output power.
    - 2) If multiple configurations have the same specified maximum output power and largest channel bandwidth, the lowest order modulation among the largest channel bandwidth configurations is selected.
    - 3) If multiple configurations have the same specified maximum output power, largest channel bandwidth and lowest order modulation, the lowest data rate configuration among these configurations is selected.
    - 4) When multiple transmission modes (802.11a/g/n/ac/ax) have the same specified maximum output power, largest channel bandwidth, lowest order modulation and lowest data rate, lowest order 802.11 mode is selected; (i.e. a/g/n/ac/ax).
  - b. After an initial test configuration is determined, if multiple test channels have the same measured maximum output power, the channel chosen for SAR measurement is determined according to the following. These channel selection procedures apply to both the initial test configuration and subsequent test configuration(s) selection.
    - 1) The channel closest to mid-band frequency is selected for SAR measurement.
    - 2) For channels with equal separation from mid-band frequency; for example, high and low channels or two mid-band channels, the higher frequency (number) channel is selected for SAR measurement.



## 12.1 Body SAR Measurement

| Measurement Results |             |                |           |      |           |                 |              |                          |                 |             |              |                            |       |
|---------------------|-------------|----------------|-----------|------|-----------|-----------------|--------------|--------------------------|-----------------|-------------|--------------|----------------------------|-------|
| Index               | Band        | Mode           | Frequency |      | Data Rate | Test Position   | Spacing (mm) | SAR <sub>1g</sub> (W/Kg) | Burst Avg Power | Max tune-up | Duty Cycle % | Reported SAR <sub>1g</sub> | Note  |
|                     |             |                | Ch.       | MHz  |           |                 |              |                          |                 |             |              |                            |       |
| #200                | WLAN 2.4GHz | 802.11b        | 6         | 2437 | 1 Mbps    | Horizontal-UP   | 5            | 0.603                    | 17.21           | 18          | 99.80        | 0.73                       | Ant 0 |
| #203                | WLAN 2.4GHz | 802.11b        | 6         | 2437 | 1 Mbps    | Horizontal-Down | 5            | 0.554                    | 17.21           | 18          | 99.80        | 0.67                       | Ant 0 |
| #204                | WLAN 2.4GHz | 802.11b        | 6         | 2437 | 1 Mbps    | Vertical-Front  | 5            | 0.217                    | 17.21           | 18          | 99.80        | 0.26                       | Ant 0 |
| #207                | WLAN 2.4GHz | 802.11b        | 6         | 2437 | 1 Mbps    | Vertical-Back   | 5            | 0.162                    | 17.21           | 18          | 99.80        | 0.20                       | Ant 0 |
| #208                | WLAN 2.4GHz | 802.11b        | 6         | 2437 | 1 Mbps    | Tip             | 5            | 0.039                    | 17.21           | 18          | 99.80        | 0.05                       | Ant 0 |
| #211                | WLAN 2.4GHz | 802.11b        | 6         | 2437 | 1 Mbps    | Bottom          | 5            | 0.028                    | 17.21           | 18          | 99.80        | 0.03                       | Ant 0 |
| #301                | WLAN 2.4GHz | 802.11g        | 6         | 2437 | 6 Mbps    | Horizontal-UP   | 5            | 0.799                    | 18.94           | 19          | 99.90        | 0.81                       | Ant 0 |
| #302                | WLAN 2.4GHz | 802.11g        | 6         | 2437 | 6 Mbps    | Horizontal-Down | 5            | 0.754                    | 18.94           | 19          | 99.90        | 0.77                       | Ant 0 |
| #303                | WLAN 2.4GHz | 802.11g        | 6         | 2437 | 6 Mbps    | Vertical-Front  | 5            | 0.289                    | 18.94           | 19          | 99.90        | 0.29                       | Ant 0 |
| #304                | WLAN 2.4GHz | 802.11g        | 6         | 2437 | 6 Mbps    | Vertical-Back   | 5            | 0.216                    | 18.94           | 19          | 99.90        | 0.22                       | Ant 0 |
| #305                | WLAN 2.4GHz | 802.11g        | 6         | 2437 | 6 Mbps    | Tip             | 5            | 0.052                    | 18.94           | 19          | 99.90        | 0.05                       | Ant 0 |
| #306                | WLAN 2.4GHz | 802.11g        | 6         | 2437 | 6 Mbps    | Bottom          | 5            | 0.037                    | 18.94           | 19          | 99.90        | 0.04                       | Ant 0 |
| #201                | WLAN 2.4GHz | 802.11n 20 MHz | 6         | 2437 | HT0       | Horizontal-UP   | 5            | 0.621                    | 18.54           | 19          | 93.69        | 0.74                       | Ant 1 |
| #202                | WLAN 2.4GHz | 802.11n 20 MHz | 6         | 2437 | HT0       | Horizontal-Down | 5            | 0.587                    | 18.54           | 19          | 93.69        | 0.70                       | Ant 1 |
| #205                | WLAN 2.4GHz | 802.11n 20 MHz | 6         | 2437 | HT0       | Vertical-Front  | 5            | 0.155                    | 18.54           | 19          | 93.69        | 0.18                       | Ant 1 |
| #206                | WLAN 2.4GHz | 802.11n 20 MHz | 6         | 2437 | HT0       | Vertical-Back   | 5            | 0.117                    | 18.54           | 19          | 93.69        | 0.14                       | Ant 1 |
| #209                | WLAN 2.4GHz | 802.11n 20 MHz | 6         | 2437 | HT0       | Tip             | 5            | 0.013                    | 18.54           | 19          | 93.69        | 0.02                       | Ant 1 |
| #210                | WLAN 2.4GHz | 802.11n 20 MHz | 6         | 2437 | HT0       | Bottom          | 5            | 0.023                    | 18.54           | 19          | 93.69        | 0.03                       | Ant 1 |





| Measurement Results |           |                 |           |      |           |                 |              |                          |                 |             |              |                            |       |
|---------------------|-----------|-----------------|-----------|------|-----------|-----------------|--------------|--------------------------|-----------------|-------------|--------------|----------------------------|-------|
| Index               | Band      | Mode            | Frequency |      | Data Rate | Test Position   | Spacing (mm) | SAR <sub>1g</sub> (W/Kg) | Burst Avg Power | Max tune-up | Duty Cycle % | Reported SAR <sub>1g</sub> | Note  |
|                     |           |                 | Ch.       | MHz  |           |                 |              |                          |                 |             |              |                            |       |
| #02                 | WLAN 5GHz | 802.11ac 80 MHz | 42        | 5210 | VHT0      | Horizontal-UP   | 5            | 0.588                    | 10.31           | 10.5        | 87.07        | 0.71                       | Ant 0 |
| #11                 | WLAN 5GHz | 802.11ac 80 MHz | 42        | 5210 | VHT0      | Horizontal-Down | 5            | 0.562                    | 10.31           | 10.5        | 87.07        | 0.68                       | Ant 0 |
| #14                 | WLAN 5GHz | 802.11ac 80 MHz | 42        | 5210 | VHT0      | Vertical-Front  | 5            | 0.226                    | 10.31           | 10.5        | 87.07        | 0.27                       | Ant 0 |
| #25                 | WLAN 5GHz | 802.11ac 80 MHz | 42        | 5210 | VHT0      | Vertical-Back   | 5            | 0.372                    | 10.31           | 10.5        | 87.07        | 0.45                       | Ant 0 |
| #26                 | WLAN 5GHz | 802.11ac 80 MHz | 42        | 5210 | VHT0      | Tip             | 5            | 0.04                     | 10.31           | 10.5        | 87.07        | 0.05                       | Ant 0 |
| #32                 | WLAN 5GHz | 802.11ac 80 MHz | 42        | 5210 | VHT0      | Bottom          | 5            | 0.02                     | 10.31           | 10.5        | 87.07        | 0.02                       | Ant 0 |
| #03                 | WLAN 5GHz | 802.11ac 80 MHz | 155       | 5775 | VHT0      | Horizontal-UP   | 5            | 0.54                     | 10.47           | 11          | 87.03        | 0.70                       | Ant 0 |
| #12                 | WLAN 5GHz | 802.11ac 80 MHz | 155       | 5775 | VHT0      | Horizontal-Down | 5            | 0.528                    | 10.47           | 11          | 87.03        | 0.69                       | Ant 0 |
| #15                 | WLAN 5GHz | 802.11ac 80 MHz | 155       | 5775 | VHT0      | Vertical-Front  | 5            | 0.346                    | 10.47           | 11          | 87.03        | 0.45                       | Ant 0 |
| #24                 | WLAN 5GHz | 802.11ac 80 MHz | 155       | 5775 | VHT0      | Vertical-Back   | 5            | 0.328                    | 10.47           | 11          | 87.03        | 0.43                       | Ant 0 |
| #27                 | WLAN 5GHz | 802.11ac 80 MHz | 155       | 5775 | VHT0      | Tip             | 5            | 0.051                    | 10.47           | 11          | 87.03        | 0.07                       | Ant 0 |
| #35                 | WLAN 5GHz | 802.11ac 80 MHz | 155       | 5775 | VHT0      | Bottom          | 5            | 0.025                    | 10.47           | 11          | 87.03        | 0.03                       | Ant 0 |
| #04                 | WLAN 5GHz | 802.11n 40 MHz  | 46        | 5230 | HT0       | Horizontal-UP   | 5            | 0.596                    | 14.49           | 15          | 93.48        | 0.72                       | Ant 1 |
| #13                 | WLAN 5GHz | 802.11n 40 MHz  | 46        | 5230 | HT0       | Horizontal-Down | 5            | 0.471                    | 14.49           | 15          | 93.48        | 0.57                       | Ant 1 |
| #16                 | WLAN 5GHz | 802.11n 40 MHz  | 46        | 5230 | HT0       | Vertical-Front  | 5            | 0.238                    | 14.49           | 15          | 93.48        | 0.29                       | Ant 1 |
| #23                 | WLAN 5GHz | 802.11n 40 MHz  | 46        | 5230 | HT0       | Vertical-Back   | 5            | 0.265                    | 14.49           | 15          | 93.48        | 0.32                       | Ant 1 |
| #28                 | WLAN 5GHz | 802.11n 40 MHz  | 46        | 5230 | HT0       | Tip             | 5            | 0.019                    | 14.49           | 15          | 93.48        | 0.02                       | Ant 1 |
| #36                 | WLAN 5GHz | 802.11n 40 MHz  | 46        | 5230 | HT0       | Bottom          | 5            | 0.04                     | 14.49           | 15          | 93.48        | 0.05                       | Ant 1 |
| #05                 | WLAN 5GHz | 802.11ac 80 MHz | 155       | 5775 | VHT0      | Horizontal-UP   | 5            | 0.583                    | 9.88            | 10.5        | 87.03        | 0.77                       | Ant 1 |
| #10                 | WLAN 5GHz | 802.11ac 80 MHz | 155       | 5775 | VHT0      | Horizontal-Down | 5            | 0.55                     | 9.88            | 10.5        | 87.03        | 0.73                       | Ant 1 |
| #17                 | WLAN 5GHz | 802.11ac 80 MHz | 155       | 5775 | VHT0      | Vertical-Front  | 5            | 0.221                    | 9.88            | 10.5        | 87.03        | 0.29                       | Ant 1 |
| #22                 | WLAN 5GHz | 802.11ac 80 MHz | 155       | 5775 | VHT0      | Vertical-Back   | 5            | 0.286                    | 9.88            | 10.5        | 87.03        | 0.38                       | Ant 1 |
| #29                 | WLAN 5GHz | 802.11ac 80 MHz | 155       | 5775 | VHT0      | Tip             | 5            | 0.024                    | 9.88            | 10.5        | 87.03        | 0.03                       | Ant 1 |

## 12.2 SAR Exposure Limit

| Human Exposure   | Population<br>Uncontrolled<br>Exposure<br>(W/kg) | Occupational<br>Controlled<br>Exposure<br>(W/kg) |
|--|--|--|
| Spatial Peak SAR*<br>(head or Body)                    | 1.60   | 8.00   |
| Spatial Peak SAR**<br>(Whole Body)                     | 0.08   | 0.40   |
| Spatial Peak SAR***<br>(Hands / Feet / Ankle / Wrist ) | 4.00   | 20.00  |

Table 2. Safety Limits for Controlled / Uncontrolled Environment Exposure

### Notes :

- \* The Spatial Peak value of the SAR averaged over any 1 gram of tissue.  
( defined as a tissue volume in the shape of a cube ) and over the appropriate averaging time.
- \*\* The Spatial Average value of the SAR averaged over the whole – body.
- \*\*\* The Spatial Peak value of the SAR averaged over any 10 grams of tissue.  
( defined as a tissue volume in the shape of a cube ) and over the appropriate averaging time.

**Population / Uncontrolled Environments :** are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure.

**Occupational / 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).



### 13. References

- [1] Std. C95.1-1999, "American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 300KHz to 100GHz", New York.
- [2] NCRP, National Council on Radiation Protection and Measurements, "Biological Effects and Exposure Criteria for Radio frequency Electromagnetic Fields", NCRP report NO. 86, 1986.
- [3] T. Schmid, O. Egger, and N. Kuster, "Automatic E-field scanning system for dosimetric assessments", IEEE Transactions on Microwave Theory and Techniques, vol. 44, pp, 105-113, Jan. 1996.
- [4] K. Pokovi<sup>c</sup>, T. Schmid, and N. Kuster, "Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequency", in ICECOM'97, Dubrovnik, October 15-17, 1997, pp.120-124.
- [5] K. Pokovi<sup>c</sup>, T. Schmid, and N. Kuster, "E-field probe with improved isotropy in brain simulating liquids", in Proceedings of the ELMAR, Zadar, Croatia, 23-25 June, 1996, pp.172-175.
- [6] N. Kuster, and Q. Balzano, "Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300MHz", IEEE Transaction on Vehicular Technology, vol. 41, no. 1, Feb. 1992, pp. 17-23.
- [7] Robert J. Renka, "Multivariate Interpolation Of Large Sets Of Scattered Data", University of North Texas ACM Transactions on Mathematical Software, vol. 14, no. 2, June 1988 , pp. 139-148.
- [8] N. Kuster, R. Kastle, T. Schmid, Dosimetric evaluation of mobile communications equipment with known precision, IEEE Transaction on Communications, vol. E80-B, no. 5, May 1997, pp. 645-652.
- [9] Std. C95.3-1991, "IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave, New York: IEEE, Aug. 1992.
- [10] CENELEC CLC/SC111B, European Prestandard (prENV 50166-2), Human Exposure to Electromagnetic Fields High-frequency: 10KHz-300GHz, Jan. 1995.
- [11] IEEE Std 1528™-2013 - IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head From Wireless Communications Devices: Measurement Techniques

## Appendix A - System Performance Check

Test Laboratory: A Test Lab Techno Corp.

Date: 2020/10/4

System Performance Check at 2450MHz\_Head

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:712**

Communication System: UID 0, CW (0); Frequency: 2450 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.85$  S/m;  $\epsilon_r = 39.491$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(7.38, 7.38, 7.38) @ 2450 MHz; Calibrated: 2020/5/20
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn541; Calibrated: 2020/3/18
- Phantom: ELI V4.0 (20deg probe tilt); Type: QD OVA 001 BB; Serial: 1036
- Measurement SW: DASY52, Version 52.10 (3); SEMCAD X Version 14.6.10 (7331)

**System Performance Check at 2450MHz/Area Scan (81x81x1):** Interpolated grid:  $dx=1.200$  mm,  $dy=1.200$  mm

Maximum value of SAR (interpolated) = 22.6 W/kg

**System Performance Check at 2450MHz/Zoom Scan (7x7x7)/Cube 0:** Measurement grid:  $dx=5$ mm,  $dy=5$ mm,  $dz=5$ mm

Reference Value = 111.5 V/m; Power Drift = -0.01 dB

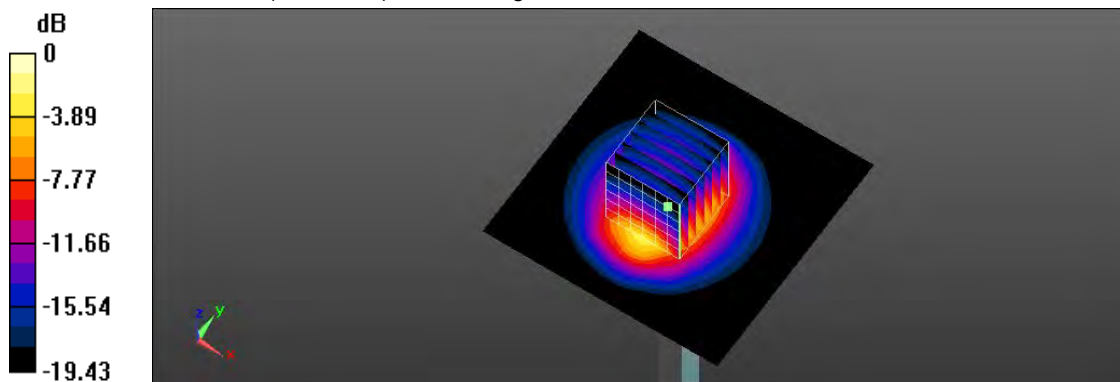
Peak SAR (extrapolated) = 27.5 W/kg

**SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.36 W/kg**

Smallest distance from peaks to all points 3 dB below = 9 mm

Ratio of SAR at M2 to SAR at M1 = 49.1%

Maximum value of SAR (measured) = 22.4 W/kg



0 dB = 22.4 W/kg = 13.50 dBW/kg

Test Laboratory: A Test Lab Techno Corp.

Date: 2020/9/29

System Performance Check at 5250MHz\_Head

**DUT: Dipole 5GHzV2; Type: D5GHz; Serial: 1021**

Communication System: UID 0, CW (0); Frequency: 5250 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 5250$  MHz;  $\sigma = 4.658$  S/m;  $\epsilon_r = 37.026$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(5.19, 5.19, 5.19) @ 5250 MHz; Calibrated: 2020/5/20
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn541; Calibrated: 2020/3/18
- Phantom: ELI V4.0 (20deg probe tilt); Type: QD OVA 001 BB; Serial: 1036
- Measurement SW: DASY52, Version 52.10 (3); SEMCAD X Version 14.6.10 (7331)

**System Performance Check at 5250MHz/Area Scan (91x91x1):** Interpolated grid:  $dx=1.000$  mm,  $dy=1.000$  mm

Maximum value of SAR (interpolated) = 17.9 W/kg

**System Performance Check at 5250MHz/Zoom Scan (7x7x7)/Cube 0:** Measurement grid:  $dx=4$ mm,  $dy=4$ mm,  $dz=1.4$ mm

Reference Value = 66.18 V/m; Power Drift = 0.06 dB

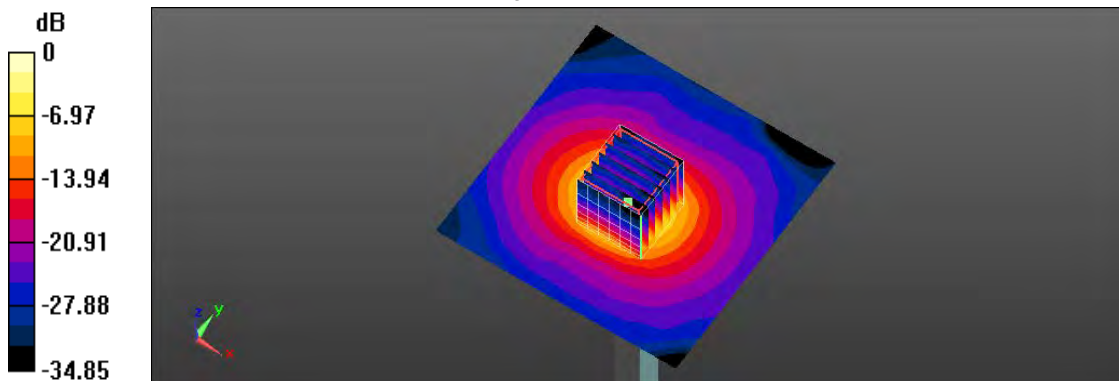
Peak SAR (extrapolated) = 31.0 W/kg

**SAR(1 g) = 7.7 W/kg; SAR(10 g) = 2.16 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 65.2%

Maximum value of SAR (measured) = 18.9 W/kg



0 dB = 18.9 W/kg = 12.76 dBW/kg

Test Laboratory: A Test Lab Techno Corp.

Date: 2020/9/29

System Performance Check at 5750MHz\_Head

**DUT: Dipole 5GHzV2; Type: D5GHz; Serial: 1021**

Communication System: UID 0, CW (0); Frequency: 5750 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 5750$  MHz;  $\sigma = 5.279$  S/m;  $\epsilon_r = 36.01$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASYS (IEEE/IEC/ANSI C63.19-2007)

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(4.65, 4.65, 4.65) @ 5750 MHz; Calibrated: 2020/5/20
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn541; Calibrated: 2020/3/18
- Phantom: ELI V4.0 (20deg probe tilt); Type: QD OVA 001 BB; Serial: 1036
- Measurement SW: DASYS2, Version 52.10 (3); SEMCAD X Version 14.6.10 (7331)

**System Performance Check at 5750MHz/Area Scan (91x91x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 19.2 W/kg

**System Performance Check at 5750MHz/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 65.00 V/m; Power Drift = 0.01 dB

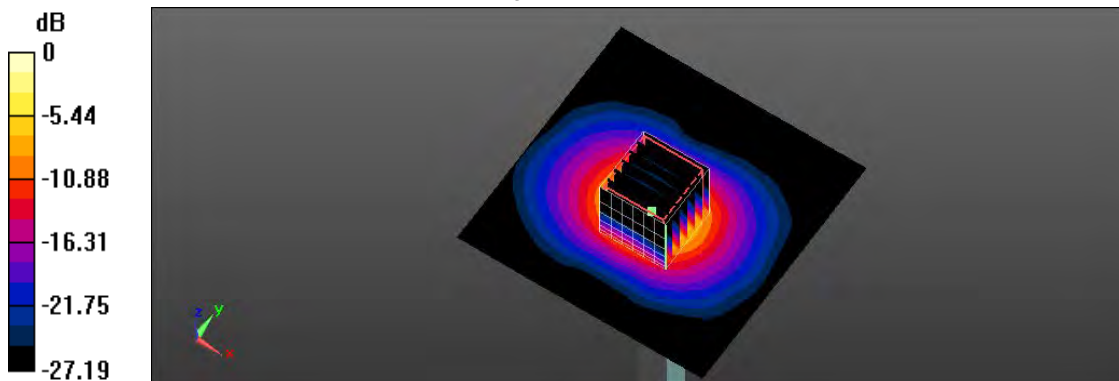
Peak SAR (extrapolated) = 34.8 W/kg

**SAR(1 g) = 8 W/kg; SAR(10 g) = 2.19 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 62.9%

Maximum value of SAR (measured) = 20.9 W/kg



0 dB = 20.9 W/kg = 13.20 dBW/kg

## Appendix B - SAR Measurement Data

Test Laboratory: A Test Lab Techno Corp.

Date: 2020/10/4

301\_IEEE 802.11g CH 6\_6M\_Horizontal-UP\_5mm\_Ant 0

**DUT: EW-7822UAC V2.0A, EW-7822UAD; Type: 11ac 2T2R Wireless Dual-Band USB Adapter**

Communication System: UID 0, IEEE 802.11b (0); Frequency: 2437 MHz; Duty Cycle: 1:1.001

Medium parameters used (interpolated):  $f = 2437$  MHz;  $\sigma = 1.837$  S/m;  $\epsilon_r = 39.529$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(7.38, 7.38, 7.38) @ 2437 MHz; Calibrated: 2020/5/20
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn541; Calibrated: 2020/3/18
- Phantom: ELI V4.0 (20deg probe tilt); Type: QD OVA 001 BB; Serial: 1036
- Measurement SW: DASY52, Version 52.10 (3); SEMCAD X Version 14.6.10 (7331)

**Area Scan (51x71x1):** Interpolated grid:  $dx=1.200$  mm,  $dy=1.200$  mm

Maximum value of SAR (interpolated) = 1.01 W/kg

**Zoom Scan (7x7x7)/Cube 0:** Measurement grid:  $dx=5$ mm,  $dy=5$ mm,  $dz=5$ mm

Reference Value = 27.54 V/m; Power Drift = -0.10 dB

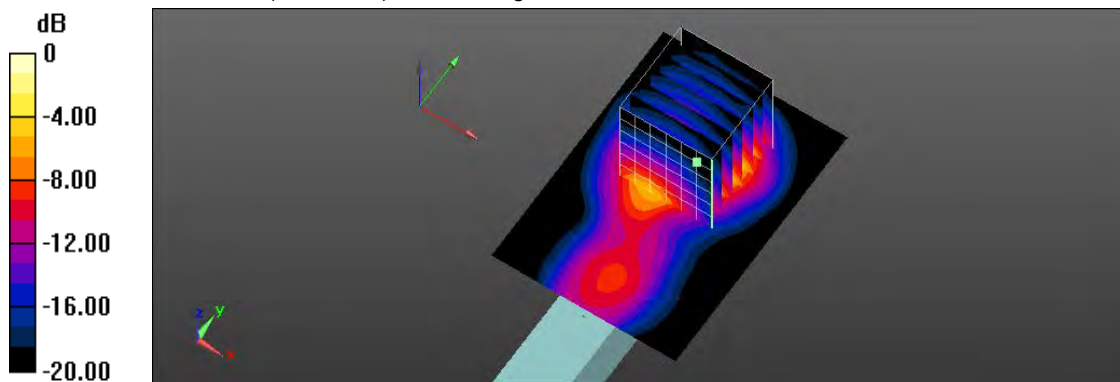
Peak SAR (extrapolated) = 1.49 W/kg

**SAR(1 g) = 0.799 W/kg; SAR(10 g) = 0.331 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 41.7%

Maximum value of SAR (measured) = 1.12 W/kg



0 dB = 1.12 W/kg = 0.49 dBW/kg

Test Laboratory: A Test Lab Techno Corp.

Date: 2020/10/4

201\_IEEE 802.11n 20 CH 6\_HT0\_Horizontal-UP\_5mm\_Ant 1

**DUT: EW-7822UAC V2.0A, EW-7822UAD; Type: 11ac 2T2R Wireless Dual-Band USB Adapter**

Communication System: UID 0, IEEE 802.11n(2.4GHz) (0); Frequency: 2437 MHz; Duty Cycle: 1:1.067

Medium parameters used (interpolated):  $f = 2437$  MHz;  $\sigma = 1.837$  S/m;  $\epsilon_r = 39.529$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(7.38, 7.38, 7.38) @ 2437 MHz; Calibrated: 2020/5/20
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn541; Calibrated: 2020/3/18
- Phantom: ELI V4.0 (20deg probe tilt); Type: QD OVA 001 BB; Serial: 1036
- Measurement SW: DASY52, Version 52.10 (3); SEMCAD X Version 14.6.10 (7331)

**Area Scan (51x71x1):** Interpolated grid:  $dx=1.200$  mm,  $dy=1.200$  mm

Maximum value of SAR (interpolated) = 1.29 W/kg

**Zoom Scan (7x7x7)/Cube 0:** Measurement grid:  $dx=5$ mm,  $dy=5$ mm,  $dz=5$ mm

Reference Value = 21.64 V/m; Power Drift = -0.10 dB

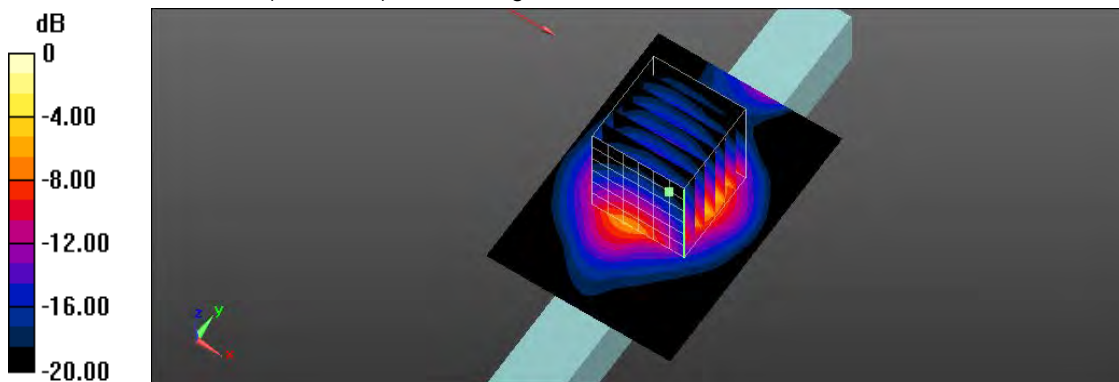
Peak SAR (extrapolated) = 1.53 W/kg

**SAR(1 g) = 0.621 W/kg; SAR(10 g) = 0.250 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.8 mm

Ratio of SAR at M2 to SAR at M1 = 42.7%

Maximum value of SAR (measured) = 1.16 W/kg



0 dB = 1.16 W/kg = 0.64 dBW/kg

Test Laboratory: A Test Lab Techno Corp.

Date: 2020/9/29

02\_IEEE 802.11ac 80 CH 42\_VHT0\_Horizontal-UP\_5mm\_Ant 0

**DUT: EW-7822UAC V2.0A, EW-7822UAD; Type: 11ac 2T2R Wireless Dual-Band USB Adapter**

Communication System: UID 0, IEEE 802.11ac(5GHz)VHT80 (0); Frequency: 5210 MHz;Duty Cycle: 1:1.149

Medium parameters used:  $f = 5210$  MHz;  $\sigma = 4.608$  S/m;  $\epsilon_r = 37.105$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within:2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(5.19, 5.19, 5.19) @ 5210 MHz; Calibrated: 2020/5/20
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn541; Calibrated: 2020/3/18
- Phantom: ELI V4.0 (20deg probe tilt); Type: QD OVA 001 BB; Serial: 1036
- Measurement SW: DASY52, Version 52.10 (3); SEMCAD X Version 14.6.10 (7331)

**Area Scan (61x121x1):** Interpolated grid:  $dx=1.000$  mm,  $dy=1.000$  mm

Maximum value of SAR (interpolated) = 1.40 W/kg

**Zoom Scan (7x7x7)/Cube 0:** Measurement grid:  $dx=4$ mm,  $dy=4$ mm,  $dz=1.4$ mm

Reference Value = 16.91 V/m; Power Drift = -0.03 dB

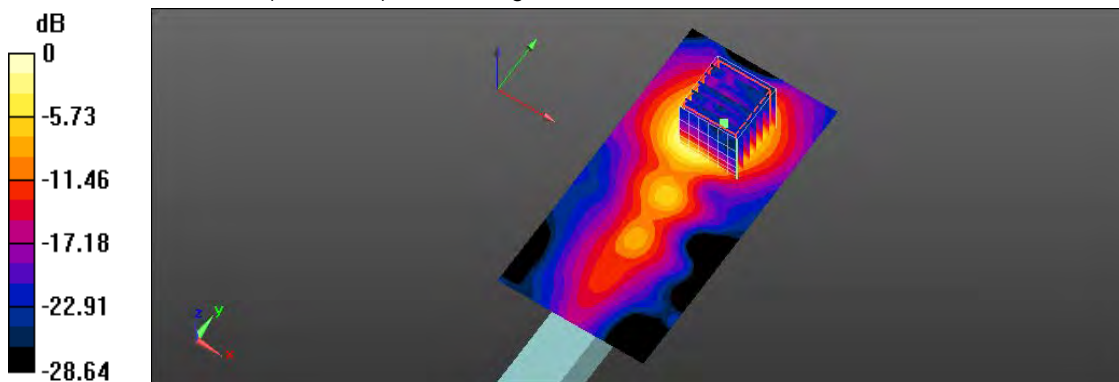
Peak SAR (extrapolated) = 2.27 W/kg

**SAR(1 g) = 0.588 W/kg; SAR(10 g) = 0.200 W/kg**

Smallest distance from peaks to all points 3 dB below = 8.8 mm

Ratio of SAR at M2 to SAR at M1 = 63.5%

Maximum value of SAR (measured) = 1.35 W/kg



0 dB = 1.35 W/kg = 1.30 dBW/kg



Test Laboratory: A Test Lab Techno Corp.

Date: 2020/9/29

03\_IEEE 802.11ac 80 CH 155\_VHT0\_Horizontal-UP\_5mm\_Ant 0

**DUT: EW-7822UAC V2.0A, EW-7822UAD; Type: 11ac 2T2R Wireless Dual-Band USB Adapter**

Communication System: UID 0, IEEE 802.11ac(5GHz)VHT80 (0); Frequency: 5775 MHz;Duty Cycle: 1:1.149

Medium parameters used:  $f = 5775$  MHz;  $\sigma = 5.242$  S/m;  $\epsilon_r = 36.07$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within:2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(4.65, 4.65, 4.65) @ 5775 MHz; Calibrated: 2020/5/20
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn541; Calibrated: 2020/3/18
- Phantom: ELI V4.0 (20deg probe tilt); Type: QD OVA 001 BB; Serial: 1036
- Measurement SW: DASY52, Version 52.10 (3); SEMCAD X Version 14.6.10 (7331)

**Area Scan (61x81x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 1.40 W/kg

**Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 13.81 V/m; Power Drift = -0.04 dB

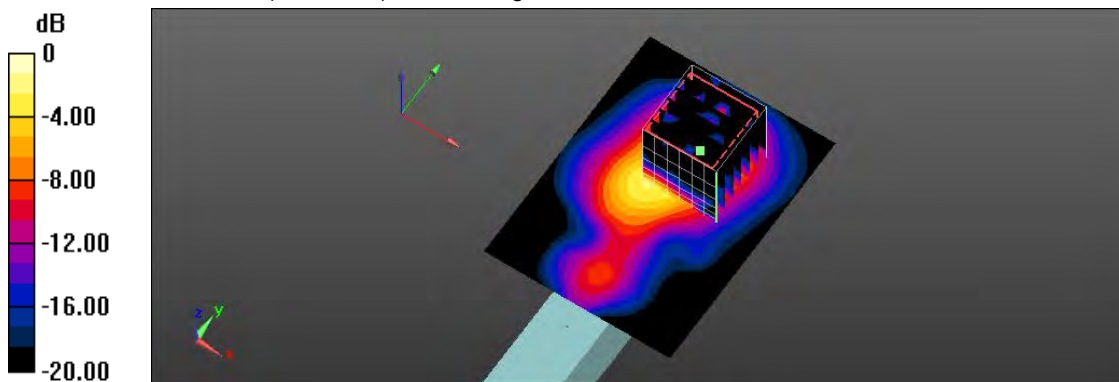
Peak SAR (extrapolated) = 2.39 W/kg

**SAR(1 g) = 0.540 W/kg; SAR(10 g) = 0.151 W/kg**

Smallest distance from peaks to all points 3 dB below = 8.5 mm

Ratio of SAR at M2 to SAR at M1 = 63.4%

Maximum value of SAR (measured) = 1.62 W/kg



0 dB = 1.62 W/kg = 2.10 dBW/kg



Test Laboratory: A Test Lab Techno Corp.

Date: 2020/9/29

04\_IEEE 802.11n 40 CH 46\_HT0\_Horizontal-UP\_5mm\_Ant 1

**DUT: EW-7822UAC V2.0A, EW-7822UAD; Type: 11ac 2T2R Wireless Dual-Band USB Adapter**

Communication System: UID 0, IEEE 802.11n(5GHz)HT40 (0); Frequency: 5230 MHz;Duty Cycle: 1:1.070

Medium parameters used:  $f = 5230$  MHz;  $\sigma = 4.641$  S/m;  $\epsilon_r = 37.059$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within:2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(5.19, 5.19, 5.19) @ 5230 MHz; Calibrated: 2020/5/20
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn541; Calibrated: 2020/3/18
- Phantom: ELI V4.0 (20deg probe tilt); Type: QD OVA 001 BB; Serial: 1036
- Measurement SW: DASY52, Version 52.10 (3); SEMCAD X Version 14.6.10 (7331)

**Area Scan (61x81x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 1.30 W/kg

**Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 12.14 V/m; Power Drift = 0.14 dB

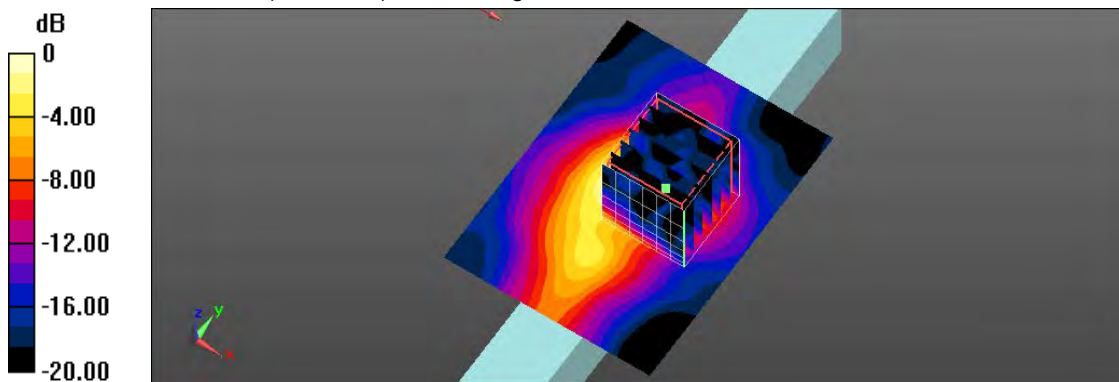
Peak SAR (extrapolated) = 2.46 W/kg

**SAR(1 g) = 0.596 W/kg; SAR(10 g) = 0.184 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.5 mm

Ratio of SAR at M2 to SAR at M1 = 63%

Maximum value of SAR (measured) = 1.40 W/kg



0 dB = 1.40 W/kg = 1.46 dBW/kg

Test Laboratory: A Test Lab Techno Corp.

Date: 2020/9/29

05\_IEEE 802.11ac 80 CH 155\_VHT0\_Horizontal-UP\_5mm\_Ant 1

**DUT: EW-7822UAC V2.0A, EW-7822UAD; Type: 11ac 2T2R Wireless Dual-Band USB Adapter**

Communication System: UID 0, IEEE 802.11ac(5GHz)VHT80 (0); Frequency: 5775 MHz;Duty Cycle: 1:1.149

Medium parameters used:  $f = 5775$  MHz;  $\sigma = 5.242$  S/m;  $\epsilon_r = 36.07$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within:2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(4.65, 4.65, 4.65) @ 5775 MHz; Calibrated: 2020/5/20
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn541; Calibrated: 2020/3/18
- Phantom: ELI V4.0 (20deg probe tilt); Type: QD OVA 001 BB; Serial: 1036
- Measurement SW: DASY52, Version 52.10 (3); SEMCAD X Version 14.6.10 (7331)

**Area Scan (61x81x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 1.79 W/kg

**Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 12.80 V/m; Power Drift = -0.17 dB

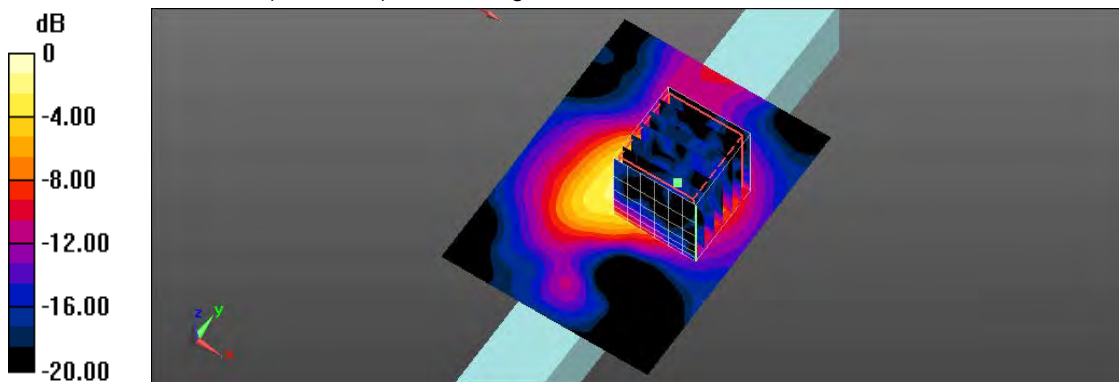
Peak SAR (extrapolated) = 2.80 W/kg

**SAR(1 g) = 0.583 W/kg; SAR(10 g) = 0.163 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 60.1%

Maximum value of SAR (measured) = 1.56 W/kg



0 dB = 1.56 W/kg = 1.93 dBW/kg



## ***Appendix C - Calibration***

All of the instruments Calibration information are listed below.

- Dipole \_ D2450V2 SN: 712
- Dipole \_ D5GHzV2 SN: 1021
- Probe \_ EX3DV4 SN: 3847
- DAE \_ DAE4 SN: 541



Client ATL

Certificate No: Z20-60163

## CALIBRATION CERTIFICATE

Object D2450V2 - SN: 712

Calibration Procedure(s) FF-Z11-003-01  
Calibration Procedures for dipole validation kits



Calibration date: April 26, 2020

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)°C and humidity<70%.

Calibration Equipment used (M&amp;TE critical for calibration)

| Primary Standards       | ID #       | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
|-------------------------|------------|--|-----------------------|
| Power Meter NRP2        | 106277     | 04-Sep-19 (CTTL, No.J19X07825)           | Sep-20                |
| Power sensor NRP8S      | 104291     | 04-Sep-19 (CTTL, No.J19X07825)           | Sep-20                |
| ReferenceProbe EX3DV4   | SN 7307    | 24-May-19(SPEAG,No.EX3-7307_May19)       | May-20                |
| DAE4                    | SN 1555    | 22-Aug-19(CTTL-SPEAG,No.Z19-60295)       | Aug-20                |
| Secondary Standards     | ID #       | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
| Signal Generator E4438C | MY49071430 | 25-Feb-20 (CTTL, No.J20X00516)           | Feb-21                |
| NetworkAnalyzer E5071C  | MY46110673 | 10-Feb-20 (CTTL, No.J20X00515)           | Feb-21                |

|                |            |                    |   |
|----------------|------------|--------------------|---|
|                | Name       | Function           | Signature   |
| Calibrated by: | Zhao Jing  | SAR Test Engineer  |  |
| Reviewed by:   | Lin Hao    | SAR Test Engineer  |  |
| Approved by:   | Qi Dianyan | SAR Project Leader |  |

Issued: April 30, 2020

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: Z20-60163

Page 1 of 6



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E-mail: cttl@chinattl.com http://www.chinattl.cn

**Glossary:**

|       |  |
|-------|--|
| TSL   | tissue simulating liquid                   |
| ConvF | sensitivity in TSL / NORM <sub>x,y,z</sub> |
| N/A   | not applicable or not measured             |

**Calibration is Performed According to the Following Standards:**

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016
- IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
- KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

**Additional Documentation:**

- DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

- Measurement Conditions:** Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL:** The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured:** SAR measured at the stated antenna input power.
- SAR normalized:** SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters:** The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of Measurement multiplied by the coverage factor  $k=2$ , which for a normal distribution Corresponds to a coverage probability of approximately 95%.



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E-mail: cttl@chinattl.com http://www.chinattl.cn

### Measurement Conditions

DASY system configuration, as far as not given on page 1.

|                              |                          |             |
|------------------------------|--------------------------|-------------|
| DASY Version                 | DASY52                   | V52.10.4    |
| Extrapolation                | Advanced Extrapolation   |             |
| Phantom                      | Triple Flat Phantom 5.1C |             |
| Distance Dipole Center - TSL | 10 mm                    | with Spacer |
| Zoom Scan Resolution         | dx, dy, dz = 5 mm        |             |
| Frequency                    | 2450 MHz $\pm$ 1 MHz     |             |

### Head TSL parameters

The following parameters and calculations were applied.

|   | Temperature         | Permittivity   | Conductivity         |
|---|---------------------|----------------|----------------------|
| Nominal Head TSL parameters             | 22.0 °C             | 39.2           | 1.80 mho/m           |
| Measured Head TSL parameters            | (22.0 $\pm$ 0.2) °C | 39.1 $\pm$ 6 % | 1.80 mho/m $\pm$ 6 % |
| Head TSL temperature change during test | <1.0 °C             | ----           | ----                 |

### SAR result with Head TSL

| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL   | Condition          |  |
|---|--------------------|--|
| SAR measured  | 250 mW input power | 12.8 W/kg                                      |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | <b>51.2 W/kg <math>\pm</math> 18.8 % (k=2)</b> |
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | Condition          |  |
| SAR measured  | 250 mW input power | 5.89 W/kg                                      |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | <b>23.6 W/kg <math>\pm</math> 18.7 % (k=2)</b> |

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E-mail: cttl@chinattl.com http://www.chinattl.cn**Appendix (Additional assessments outside the scope of CNAS L0570)****Antenna Parameters with Head TSL**

|                                      |                |
|--------------------------------------|----------------|
| Impedance, transformed to feed point | 52.4Ω+ 3.22 jΩ |
| Return Loss                          | - 28.1dB       |

**General Antenna Parameters and Design**

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.024 ns |
|----------------------------------|----------|

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.  
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

**Additional EUT Data**

|                 |       |
|-----------------|-------|
| Manufactured by | SPEAG |
|-----------------|-------|





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# **DASY5 Validation Report for Head TSL**

Date: 04.26.2020

Test Laboratory: CTTL, Beijing, China

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 712**

Communication System: UID 0, CW; Frequency: 2450 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.796$  S/m;  $\epsilon_r = 39.05$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7307; ConvF(7.83, 7.83, 7.83) @ 2450 MHz; Calibrated: 2019-05-24
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1555; Calibrated: 2019-08-22
- Phantom: MFP\_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7483)

**Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 106.6 V/m; Power Drift = -0.03 dB

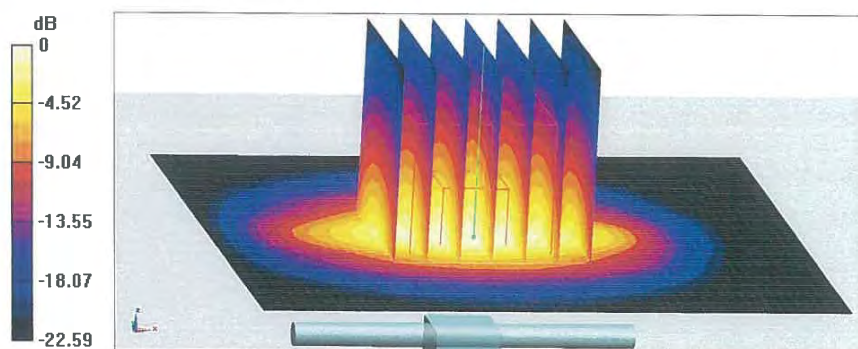
Peak SAR (extrapolated) = 27.2 W/kg

**SAR(1 g) = 12.8 W/kg; SAR(10 g) = 5.89 W/kg**

Smallest distance from peaks to all points 3 dB below = 9 mm

Ratio of SAR at M2 to SAR at M1 = 47.1%

Maximum value of SAR (measured) = 21.8 W/kg



0 dB = 21.8 W/kg = 13.38 dBW/kg

Certificate No: Z20-60163

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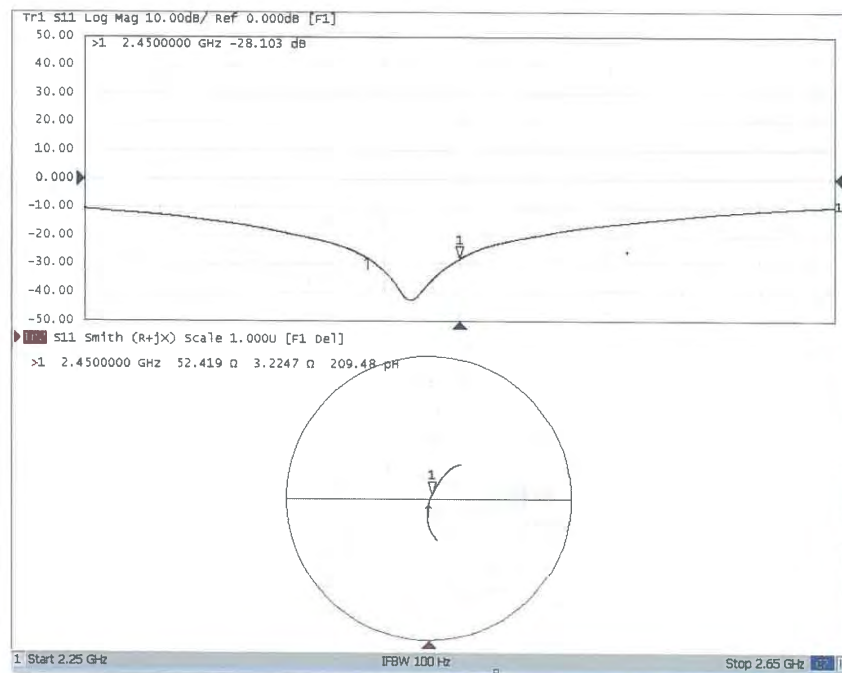




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### Impedance Measurement Plot for Head TSL





ST-007-20-071

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CNAS L0570

Client **ATL**

Certificate No: **Z20-60164**

## CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN: 1021**

Calibration Procedure(s) **FF-Z11-003-01**  
**Calibration Procedures for dipole validation kits**



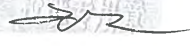
Calibration date: **April 23, 2020**

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)°C and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards       | ID #       | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
|-------------------------|------------|--|-----------------------|
| Power Meter NRP2        | 106277     | 04-Sep-19 (CTTL, No.J19X07825)           | Sep-20                |
| Power sensor NRP8S      | 104291     | 04-Sep-19 (CTTL, No.J19X07825)           | Sep-20                |
| ReferenceProbe EX3DV4   | SN 7307    | 24-May-19(SPEAG,No.EX3-7307_May19)       | May-20                |
| DAE4                    | SN 1555    | 22-Aug-19(CTTL-SPEAG,No.Z19-60295)       | Aug-20                |
| Secondary Standards     | ID #       | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
| Signal Generator E4438C | MY49071430 | 25-Feb-20 (CTTL, No.J20X00516)           | Feb-21                |
| NetworkAnalyzerE5071C   | MY46110673 | 10-Feb-20 (CTTL, No.J20X00515)           | Feb-21                |

|                | Name        | Function           | Signature   |
|----------------|-------------|--------------------|---|
| Calibrated by: | Zhao Jing   | SAR Test Engineer  |  |
| Reviewed by:   | Lin Hao     | SAR Test Engineer  |  |
| Approved by:   | Qi Dianyuan | SAR Project Leader |  |

Issued: April 30, 2020

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Certificate No: Z20-60164

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#### Glossary:

|       |  |
|-------|--|
| TSL   | tissue simulating liquid                   |
| ConvF | sensitivity in TSL / NORM <sub>x,y,z</sub> |
| N/A   | not applicable or not measured             |

#### Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016
- IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
- KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

#### Additional Documentation:

- DASY4/5 System Handbook

#### Methods Applied and Interpretation of Parameters:

- Measurement Conditions:** Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL:** The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured:** SAR measured at the stated antenna input power.
- SAR normalized:** SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters:** The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of Measurement multiplied by the coverage factor  $k=2$ , which for a normal distribution Corresponds to a coverage probability of approximately 95%.



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### Measurement Conditions

DASY system configuration, as far as not given on page 1.

|                                     |  |                                  |
|-------------------------------------|--|----------------------------------|
| <b>DASY Version</b>                 | DASY52   | V52.10.4                         |
| <b>Extrapolation</b>                | Advanced Extrapolation   |                                  |
| <b>Phantom</b>                      | Triple Flat Phantom 5.1C   |                                  |
| <b>Distance Dipole Center - TSL</b> | 10 mm  | with Spacer                      |
| <b>Zoom Scan Resolution</b>         | dx, dy = 4 mm, dz = 1.4 mm   | Graded Ratio = 1.4 (Z direction) |
| <b>Frequency</b>                    | 5250 MHz $\pm$ 1 MHz<br>5600 MHz $\pm$ 1 MHz<br>5750 MHz $\pm$ 1 MHz |                                  |

### Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

|  | Temperature         | Permittivity   | Conductivity         |
|--|---------------------|----------------|----------------------|
| <b>Nominal Head TSL parameters</b>             | 22.0 °C             | 35.9           | 4.71 mho/m           |
| <b>Measured Head TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 35.9 $\pm$ 6 % | 4.67 mho/m $\pm$ 6 % |
| <b>Head TSL temperature change during test</b> | <1.0 °C             | ----           | ----                 |

### SAR result with Head TSL at 5250 MHz

| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>   | Condition          |  |
|---|--------------------|--|
| SAR measured  | 100 mW input power | 7.55 W/kg                                      |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>75.5 W/kg <math>\pm</math> 24.4 % (k=2)</b> |
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | Condition          |  |
| SAR measured  | 100 mW input power | 2.14 W/kg                                      |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>21.4 W/kg <math>\pm</math> 24.2 % (k=2)</b> |



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#### Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

|   | Temperature     | Permittivity | Conductivity     |
|---|-----------------|--------------|------------------|
| Nominal Head TSL parameters             | 22.0 °C         | 35.5         | 5.07 mho/m       |
| Measured Head TSL parameters            | (22.0 ± 0.2) °C | 35.3 ± 6 %   | 5.05 mho/m ± 6 % |
| Head TSL temperature change during test | <1.0 °C         | ----         | ----             |

#### SAR result with Head TSL at 5600 MHz

|   |                    |                          |
|---|--------------------|--------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL   | Condition          |                          |
| SAR measured  | 100 mW input power | 7.97 W/kg                |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 79.6 W/kg ± 24.4 % (k=2) |
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | Condition          |                          |
| SAR measured  | 100 mW input power | 2.24 W/kg                |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 22.4 W/kg ± 24.2 % (k=2) |

#### Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

|   | Temperature     | Permittivity | Conductivity     |
|---|-----------------|--------------|------------------|
| Nominal Head TSL parameters             | 22.0 °C         | 35.4         | 5.22 mho/m       |
| Measured Head TSL parameters            | (22.0 ± 0.2) °C | 35.1 ± 6 %   | 5.21 mho/m ± 6 % |
| Head TSL temperature change during test | <1.0 °C         | ----         | ----             |

#### SAR result with Head TSL at 5750 MHz

|   |                    |                          |
|---|--------------------|--------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL   | Condition          |                          |
| SAR measured  | 100 mW input power | 7.62 W/kg                |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 76.0 W/kg ± 24.4 % (k=2) |
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | Condition          |                          |
| SAR measured  | 100 mW input power | 2.14 W/kg                |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 21.3 W/kg ± 24.2 % (k=2) |



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#### Appendix (Additional assessments outside the scope of CNAS L0570)

##### Antenna Parameters with Head TSL at 5250 MHz

|                                      |                |
|--------------------------------------|----------------|
| Impedance, transformed to feed point | 52.9Ω - 3.93jΩ |
| Return Loss                          | - 26.5dB       |

##### Antenna Parameters with Head TSL at 5600 MHz

|                                      |                |
|--------------------------------------|----------------|
| Impedance, transformed to feed point | 56.8Ω + 0.21jΩ |
| Return Loss                          | - 23.9dB       |

##### Antenna Parameters with Head TSL at 5750 MHz

|                                      |                |
|--------------------------------------|----------------|
| Impedance, transformed to feed point | 55.6Ω + 2.86jΩ |
| Return Loss                          | - 24.5dB       |

##### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.067 ns |
|----------------------------------|----------|

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard. No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

##### Additional EUT Data

|                 |       |
|-----------------|-------|
| Manufactured by | SPEAG |
|-----------------|-------|



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**DASY5 Validation Report for Head TSL**

Date: 04.23.2020

Test Laboratory: CTTL, Beijing, China

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1021**Communication System: CW; Frequency: 5250 MHz, Frequency: 5600 MHz,  
Frequency: 5750 MHz,Medium parameters used:  $f = 5250$  MHz;  $\sigma = 4.671$  S/m;  $\epsilon_r = 35.88$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5600$  MHz;  $\sigma = 5.048$  S/m;  $\epsilon_r = 35.28$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5750$  MHz;  $\sigma = 5.211$  S/m;  $\epsilon_r = 35.06$ ;  $\rho = 1000$  kg/m<sup>3</sup>,

Phantom section: Center Section

**DASY5 Configuration:**

- Probe: EX3DV4 - SN7307; ConvF(5.61, 5.61, 5.61) @ 5250 MHz; ConvF(5.12, 5.12, 5.12) @ 5600 MHz; ConvF(5.15, 5.15, 5.15) @ 5750 MHz; Calibrated: 2019-05-24
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1555; Calibrated: 2019-08-22
- Phantom: MFP\_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7483)

**Dipole Calibration /Pin=100mW, d=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
Reference Value = 70.74 V/m; Power Drift = -0.03 dB  
Peak SAR (extrapolated) = 32.5 W/kg  
**SAR(1 g) = 7.55 W/kg; SAR(10 g) = 2.14 W/kg**  
Smallest distance from peaks to all points 3 dB below = 7.4 mm  
Ratio of SAR at M2 to SAR at M1 = 63.5%  
Maximum value of SAR (measured) = 18.6 W/kg

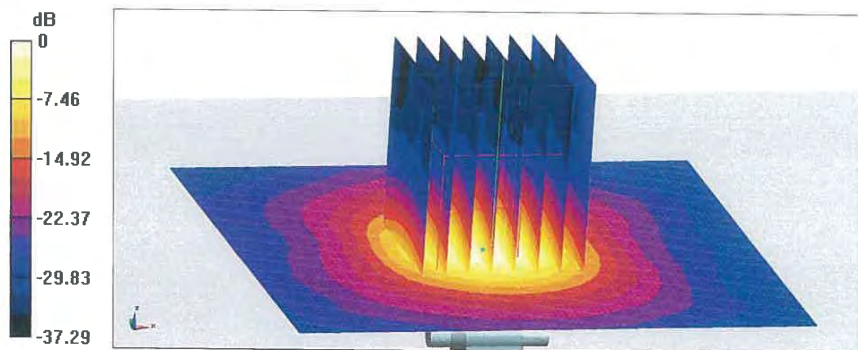
**Dipole Calibration /Pin=100mW, d=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
Reference Value = 70.28 V/m; Power Drift = -0.02 dB  
Peak SAR (extrapolated) = 37.3 W/kg  
**SAR(1 g) = 7.97 W/kg; SAR(10 g) = 2.24 W/kg**  
Smallest distance from peaks to all points 3 dB below = 7.4 mm  
Ratio of SAR at M2 to SAR at M1 = 60.6%  
Maximum value of SAR (measured) = 20.2 W/kg





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**Dipole Calibration /Pin=100mW, d=10mm, f=5750 MHz/Zoom Scan,**  
**dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
Reference Value = 68.29 V/m; Power Drift = 0.01 dB  
Peak SAR (extrapolated) = 36.8 W/kg  
**SAR(1 g) = 7.62 W/kg; SAR(10 g) = 2.14 W/kg**  
Smallest distance from peaks to all points 3 dB below = 7.4 mm  
Ratio of SAR at M2 to SAR at M1 = 59.5%  
Maximum value of SAR (measured) = 19.2 W/kg



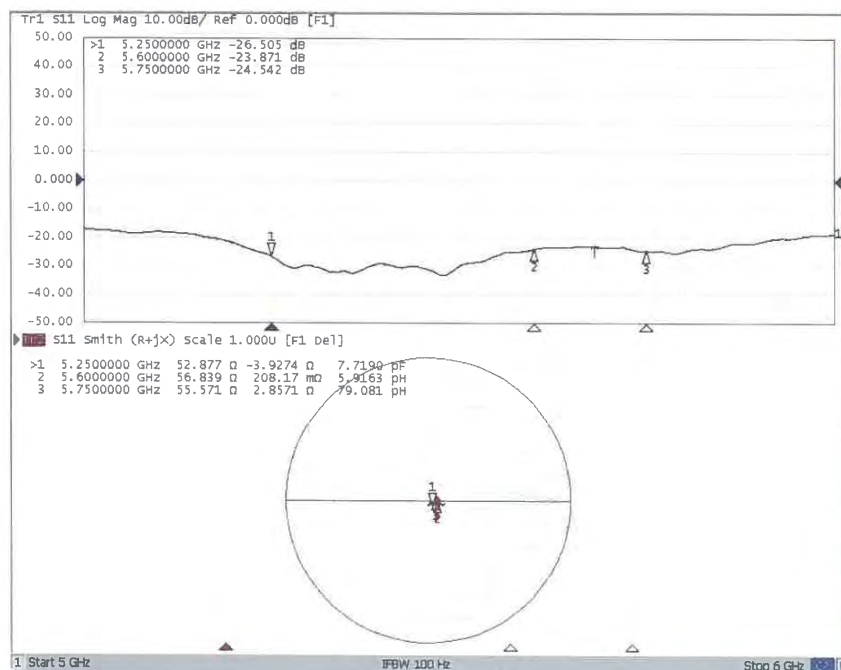
0 dB = 19.2 W/kg = 12.83 dBW/kg





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### Impedance Measurement Plot for Head TSL





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EX-042-20-107

Client **ATL**

Certificate No: **Z20-60165**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN : 3847**

Calibration Procedure(s) **FF-Z11-004-01**  
**Calibration Procedures for Dosimetric E-field Probes**

Calibration date: **May 20, 2020**

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)°C and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards        | ID #        | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
|--------------------------|-------------|--|-----------------------|
| Power Meter NRP2         | 101919      | 18-Jun-19(CTTL, No.J19X05125)            | Jun-20                |
| Power sensor NRP-Z91     | 101547      | 18-Jun-19(CTTL, No.J19X05125)            | Jun-20                |
| Power sensor NRP-Z91     | 101548      | 18-Jun-19(CTTL, No.J19X05125)            | Jun-20                |
| Reference 10dBAttenuator | 18N50W-10dB | 10-Feb-20(CTTL, No.J20X00525)            | Feb-22                |
| Reference 20dBAttenuator | 18N50W-20dB | 10-Feb-20(CTTL, No.J20X00526)            | Feb-22                |
| Reference Probe EX3DV4   | SN 3617     | 30-Jan-20(SPEAG, No.EX3-3617_Jan20/2)    | Jan-21                |
| DAE4                     | SN 1556     | 4-Feb-20(SPEAG, No.DAE4-1556_Feb20)      | Feb-21                |
| Secondary Standards      | ID #        | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
| SignalGenerator MG3700A  | 6201052605  | 18-Jun-19(CTTL, No.J19X05127)            | Jun-20                |
| Network Analyzer E5071C  | MY46110673  | 10-Feb-20(CTTL, No.J20X00515)            | Feb-21                |

|                | Name        | Function           | Signature |
|----------------|-------------|--------------------|-----------|
| Calibrated by: | Yu Zongying | SAR Test Engineer  |           |
| Reviewed by:   | Lin Hao     | SAR Test Engineer  |           |
| Approved by:   | Qi Dianyuan | SAR Project Leader |           |

Issued: May 22, 2020

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#### Glossary:

|                       |   |
|-----------------------|---|
| TSL                   | tissue simulating liquid  |
| NORM <sub>x,y,z</sub> | sensitivity in free space   |
| ConvF                 | sensitivity in TSL / NORM <sub>x,y,z</sub>  |
| DCP                   | diode compression point   |
| CF                    | crest factor (1/duty_cycle) of the RF signal  |
| A,B,C,D               | modulation dependent linearization parameters   |
| Polarization $\Phi$   | $\Phi$ rotation around probe axis   |
| Polarization $\theta$ | $\theta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), i<br>$\theta=0$ is normal to probe axis |

Connector Angle information used in DASY system to align probe sensor X to the robot coordinate system

#### Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>:** Assessed for E-field polarization  $\theta=0$  ( $f \leq 900\text{MHz}$  in TEM-cell;  $f > 1800\text{MHz}$ : waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not effect the  $E^2$ -field uncertainty inside TSL (see below ConvF).
- NORM(f)<sub>x,y,z</sub> = NORM<sub>x,y,z</sub> \* frequency\_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP<sub>x,y,z</sub>:** DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency nor media.
- PAR:** PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics.
- A<sub>x,y,z</sub>; B<sub>x,y,z</sub>; C<sub>x,y,z</sub>; VR<sub>x,y,z</sub>; A,B,C** are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters:** Assessed in flat phantom using E-field (or Temperature Transfer Standard for  $f \leq 800\text{MHz}$ ) and inside waveguide using analytical field distributions based on power measurements for  $f > 800\text{MHz}$ . The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty valued are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM<sub>x,y,z</sub> \* ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from  $\pm 50\text{MHz}$  to  $\pm 100\text{MHz}$ .
- Spherical isotropy (3D deviation from isotropy):** in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset:** The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle:** The angle is assessed using the information gained by determining the NORM<sub>x</sub> (no uncertainty required).



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## DASY/EASY – Parameters of Probe: EX3DV4 – SN:3847

### Basic Calibration Parameters

|                                      | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|--------------------------------------|----------|----------|----------|-----------|
| Norm( $\mu V/(V/m)^2$ ) <sup>A</sup> | 0.56     | 0.50     | 0.44     | ±10.0%    |
| DCP(mV) <sup>B</sup>                 | 98.7     | 99.2     | 102.8    |           |

### Modulation Calibration Parameters

| UID | Communication System Name |   | A dB | B dB/ $\mu V$ | C   | D dB | VR mV | Unc <sup>E</sup> (k=2) |
|-----|---------------------------|---|------|---------------|-----|------|-------|------------------------|
| 0   | CW                        | X | 0.0  | 0.0           | 1.0 | 0.00 | 172.6 | ±2.1%                  |
|     |                           | Y | 0.0  | 0.0           | 1.0 |      | 166.4 |                        |
|     |                           | Z | 0.0  | 0.0           | 1.0 |      | 151.0 |                        |

The reported uncertainty of measurement is stated as the standard uncertainty of Measurement multiplied by the coverage factor  $k=2$ , which for a normal distribution Corresponds to a coverage probability of approximately 95%.

<sup>A</sup> The uncertainties of Norm X, Y, Z do not affect the  $E^2$ -field uncertainty inside TSL (see Page 4).

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

<sup>E</sup> Uncertainly is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.



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## DASY/EASY – Parameters of Probe: EX3DV4 – SN:3847

### Calibration Parameter Determined in Head Tissue Simulating Media

| f [MHz] <sup>C</sup> | Relative Permittivity <sup>F</sup> | Conductivity (S/m) <sup>F</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>G</sup> | Depth <sup>G</sup> (mm) | Uct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|------------|
| 750                  | 41.9                               | 0.89                            | 9.54    | 9.54    | 9.54    | 0.40               | 0.80                    | ±12.1%     |
| 835                  | 41.5                               | 0.90                            | 9.26    | 9.26    | 9.26    | 0.13               | 1.41                    | ±12.1%     |
| 900                  | 41.5                               | 0.97                            | 9.30    | 9.30    | 9.30    | 0.27               | 0.94                    | ±12.1%     |
| 1450                 | 40.5                               | 1.20                            | 8.35    | 8.35    | 8.35    | 0.30               | 0.83                    | ±12.1%     |
| 1750                 | 40.1                               | 1.37                            | 8.14    | 8.14    | 8.14    | 0.22               | 1.11                    | ±12.1%     |
| 1810                 | 40.0                               | 1.40                            | 7.96    | 7.96    | 7.96    | 0.22               | 1.07                    | ±12.1%     |
| 1900                 | 40.0                               | 1.40                            | 7.78    | 7.78    | 7.78    | 0.22               | 1.17                    | ±12.1%     |
| 2000                 | 40.0                               | 1.40                            | 7.86    | 7.86    | 7.86    | 0.19               | 1.23                    | ±12.1%     |
| 2300                 | 39.5                               | 1.67                            | 7.57    | 7.57    | 7.57    | 0.51               | 0.71                    | ±12.1%     |
| 2450                 | 39.2                               | 1.80                            | 7.38    | 7.38    | 7.38    | 0.55               | 0.72                    | ±12.1%     |
| 2600                 | 39.0                               | 1.96                            | 7.20    | 7.20    | 7.20    | 0.63               | 0.69                    | ±12.1%     |
| 3300                 | 38.2                               | 2.71                            | 6.79    | 6.79    | 6.79    | 0.43               | 0.96                    | ±13.3%     |
| 3500                 | 37.9                               | 2.91                            | 6.74    | 6.74    | 6.74    | 0.48               | 0.90                    | ±13.3%     |
| 3700                 | 37.7                               | 3.12                            | 6.52    | 6.52    | 6.52    | 0.46               | 0.93                    | ±13.3%     |
| 3900                 | 37.5                               | 3.32                            | 6.43    | 6.43    | 6.43    | 0.40               | 1.15                    | ±13.3%     |
| 4100                 | 37.2                               | 3.53                            | 6.29    | 6.29    | 6.29    | 0.40               | 1.20                    | ±13.3%     |
| 4200                 | 37.1                               | 3.63                            | 6.20    | 6.20    | 6.20    | 0.40               | 1.20                    | ±13.3%     |
| 4400                 | 36.9                               | 3.84                            | 6.06    | 6.06    | 6.06    | 0.40               | 1.20                    | ±13.3%     |
| 4600                 | 36.7                               | 4.04                            | 6.00    | 6.00    | 6.00    | 0.55               | 1.01                    | ±13.3%     |
| 4800                 | 36.4                               | 4.25                            | 5.95    | 5.95    | 5.95    | 0.55               | 1.11                    | ±13.3%     |
| 4950                 | 36.3                               | 4.40                            | 5.80    | 5.80    | 5.80    | 0.55               | 1.11                    | ±13.3%     |
| 5250                 | 35.9                               | 4.71                            | 5.19    | 5.19    | 5.19    | 0.50               | 1.20                    | ±13.3%     |
| 5600                 | 35.5                               | 5.07                            | 4.71    | 4.71    | 4.71    | 0.55               | 1.23                    | ±13.3%     |
| 5750                 | 35.4                               | 5.22                            | 4.65    | 4.65    | 4.65    | 0.60               | 1.20                    | ±13.3%     |

<sup>C</sup> Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

<sup>F</sup> At frequency below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ±5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

<sup>G</sup> Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

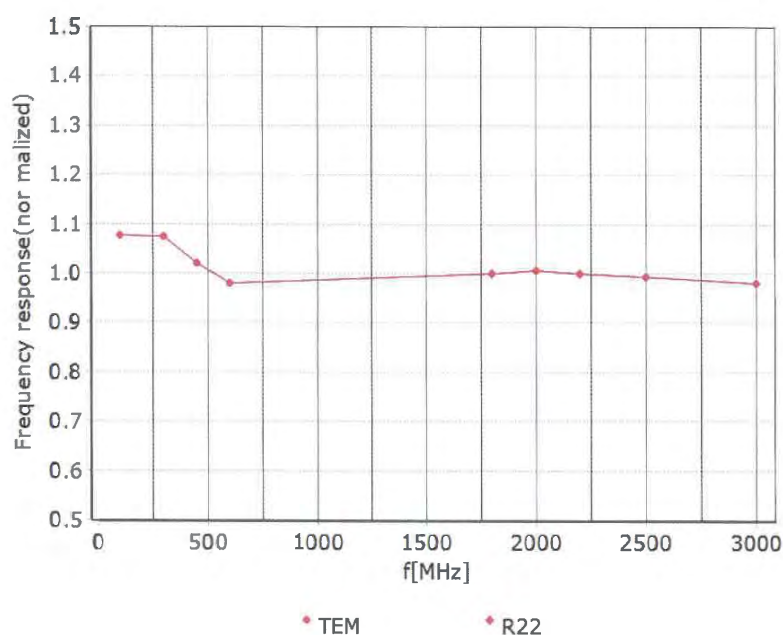
Certificate No:Z20-60165

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## Frequency Response of E-Field (TEM-Cell: ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field:  $\pm 7.4\%$  ( $k=2$ )



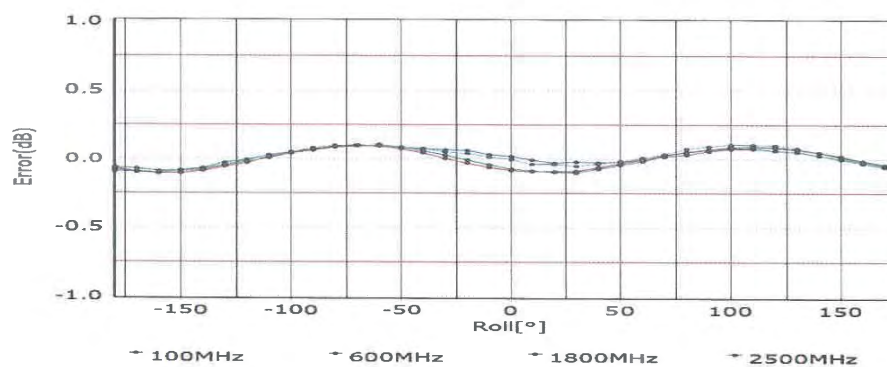
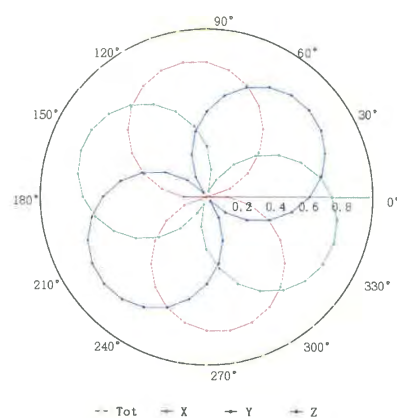
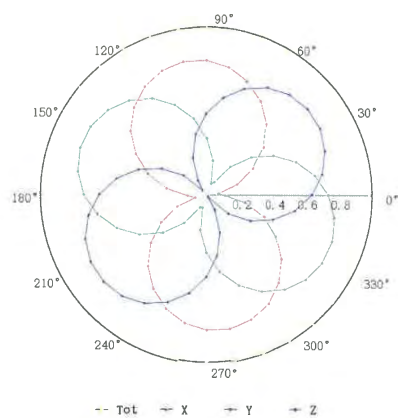


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## Receiving Pattern ( $\Phi$ ), $\theta=0^\circ$

**f=600 MHz, TEM**

**f=1800 MHz, R22**

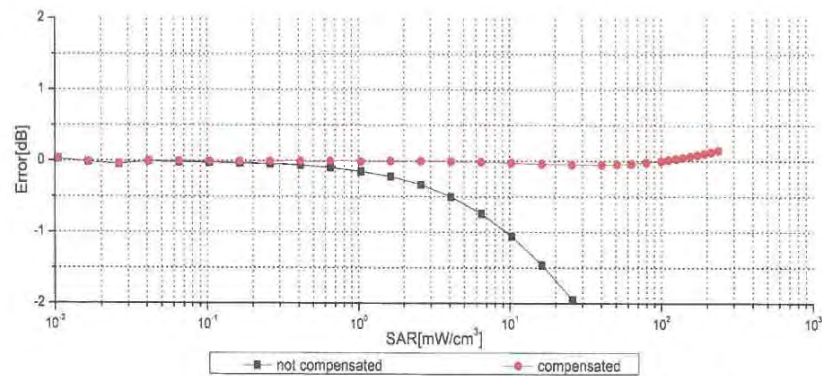
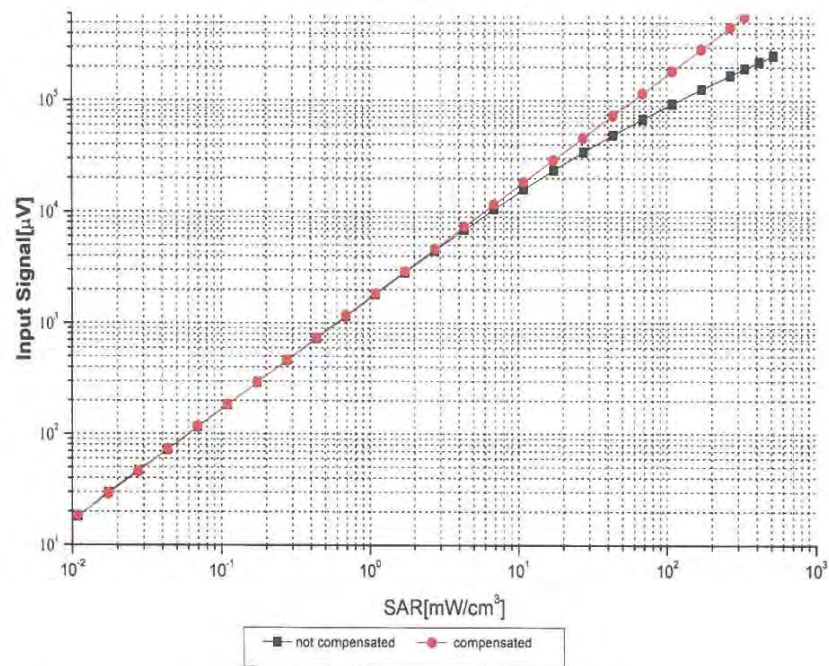


Uncertainty of Axial Isotropy Assessment:  $\pm 1.2\%$  ( $k=2$ )



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## Dynamic Range f(SAR<sub>head</sub>) (TEM cell, f = 900 MHz)



Uncertainty of Linearity Assessment:  $\pm 0.9\%$  ( $k=2$ )



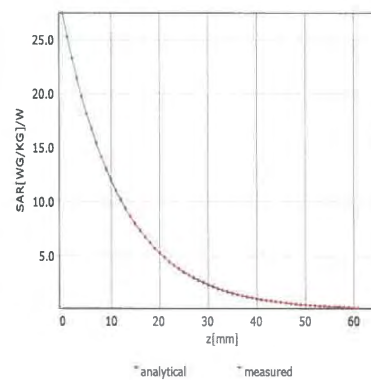
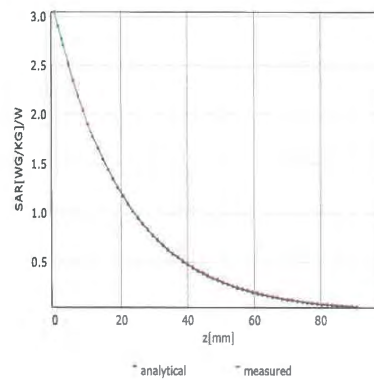


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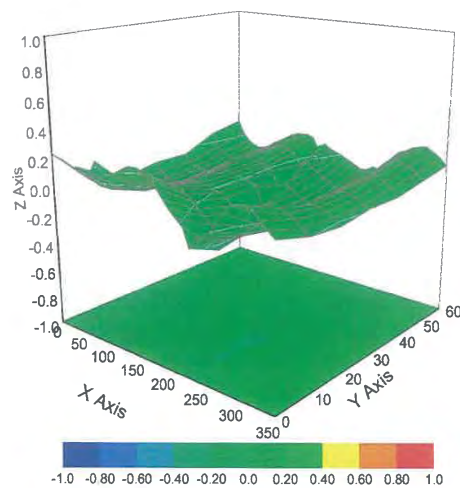
## Conversion Factor Assessment

$f=750\text{ MHz}$ , WGLS R9(H\_convF)

$f=1750\text{ MHz}$ , WGLS R22(H\_convF)



## Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment:  $\pm 3.2\%$  ( $k=2$ )



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## DASY/EASY – Parameters of Probe: EX3DV4 – SN:3847

### Other Probe Parameters

|   |            |
|---|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 100.7      |
| Mechanical Surface Detection Mode             | enabled    |
| Optical Surface Detection Mode                | disable    |
| Probe Overall Length                          | 337mm      |
| Probe Body Diameter                           | 10mm       |
| Tip Length                                    | 10mm       |
| Tip Diameter                                  | 2.5mm      |
| Probe Tip to Sensor X Calibration Point       | 1mm        |
| Probe Tip to Sensor Y Calibration Point       | 1mm        |
| Probe Tip to Sensor Z Calibration Point       | 1mm        |
| Recommended Measurement Distance from Surface | 1.4mm      |



Client : ATL

Certificate No: Z20-60115

## CALIBRATION CERTIFICATE

Object DAE4 - SN: 541

Calibration Procedure(s) FF-Z11-002-01  
Calibration Procedure for the Data Acquisition Electronics (DAEx)

Calibration date: March 18, 2020

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)℃ and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards      | ID #    | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
|------------------------|---------|--|-----------------------|
| Process Calibrator 753 | 1971018 | 24-Jun-19 (CTTL, No.J19X05126)           | Jun-20                |

|                |             |                    |           |
|----------------|-------------|--------------------|-----------|
|                | Name        | Function           | Signature |
| Calibrated by: | Yu Zongying | SAR Test Engineer  |           |
| Reviewed by:   | Lin Hao     | SAR Test Engineer  |           |
| Approved by:   | Qi Dianyuan | SAR Project Leader |           |

Issued: March 20, 2020

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



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**Glossary:**

DAE data acquisition electronics  
Connector angle information used in DASY system to align probe sensor X to the robot coordinate system.

**Methods Applied and Interpretation of Parameters:**

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The report provide only calibration results for DAE, it does not contain other performance test results.



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#### DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1μV, full range = -100...+300 mV

Low Range: 1LSB = 61nV, full range = -1.....+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X                     | Y                     | Z                     |
|---------------------|-----------------------|-----------------------|-----------------------|
| High Range          | 404.553 ± 0.15% (k=2) | 404.412 ± 0.15% (k=2) | 404.179 ± 0.15% (k=2) |
| Low Range           | 3.96888 ± 0.7% (k=2)  | 3.93481 ± 0.7% (k=2)  | 3.97551 ± 0.7% (k=2)  |

#### Connector Angle

|   |            |
|---|------------|
| Connector Angle to be used in DASY system | 288° ± 1 ° |
|---|------------|