

Withings

TEST REPORT

SCOPE OF WORK

FCC TESTING – WPA02

REPORT NUMBER

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SAR TEST REPORT

For

Withings

Product Description: Withings U-Scan Reader

FCC ID: XNAWPA02

Model No.: WPA02

Report No.: 250221042SZN-001

Issue Date: 24 March 2025

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1. General Information

| | |
|----------------------|---|
| Applicant: | Withings 2 Rue Maurice Hartmann Issy-les-Moulineaux 92130 France |
| Manufacturer: | Withings 2 Rue Maurice Hartmann Issy-les-Moulineaux 92130 France |
| Product Description: | Withings U-Scan Reader |
| Model Number: | WPA02 |
| S/N | A4:7E:FA:3C:CD:FC |
| Sample Number: | Z250221042-001 |
| File Number: | 250221042SZN-001 |
| Date of Test: | 21 February 2025 to 26 February 2025 |

The above equipment was tested by Intertek Testing Services Shenzhen Ltd. Longhua Branch. The test data, data evaluation, test procedures, and equipment configurations shown in this report were made in accordance with the procedures given in IEEE 1528-2013 and KDB 865664. This device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (1.6 W/kg) specified in ANSI/IEEE C95.1-1992.

The test results of this report relate only to the tested sample identified in this report.

2. Statement of Compliance

The Maximum reported SAR_{1g}

| Band | Mode | Test Position | Channel /Frequency (MHz) | Limit SAR _{1g} 1.6 W/kg | |
|-------------|---------|---------------|--------------------------|-----------------------------------|-----------------------------------|
| | | | | Measured SAR _{1g} (W/kg) | Reported SAR _{1g} (W/kg) |
| WIFI 2.4GHz | 802.11b | Front Side | 11/2462 | 0.00176 | 0.020 |
| BLE | 2m | Front Side | 0/2402 | 0.00498 | 0.006 |

The SAR values found for the Withings U-Scan Reader are below the maximum recommended levels of 1.6 W/kg as averaged over any 1g tissue according to the ANSI C95.1-1992.

3. Equipment Under Test (EUT) Technical Description

| Characteristics | Description | | |
|------------------------------|---|----------------------|-------------------------|
| Product Name: | Withings U-Scan Reader | | |
| Model: | WPA02 | | |
| Device type: | Mobile device | | |
| Exposure Category: | Uncontrolled Environment/General Population | | |
| Test Mode(s): | BLE(GFSK) WIFI 2.4G (DSSS/OFDM) | | |
| Device Class: | B | | |
| Antenna Type: | FCB Antenna | | |
| Antenna gain: | 4.1dBi (Max.) for 2.4GHz | | |
| Operating Frequency Range(s) | Band | Frequency Rang (MHz) | Test Channel |
| | WIFI 2.4G | 2400-2483.5 | 802.11b/g/n 20M: 1-6-11 |
| | BLE | 2400-2483.5 | 0-19-39 |
| Power supply: | D.C. 3.8V with Lithium battery | | |
| Product Software Version: | V3101 | | |
| Product Hardware Version: | V10a | | |
| SOP | RF_EMI_STM32WB_test_procedure_v7 | | |

Note:

1. NA is Not Applicable
2. For more details, please refer to the User's manual of the EUT.
3. The sample under test was selected by the Client.

4. Auxiliary Equipment Details

N/A

5. Test Facility

| Site Description | |
|------------------|---|
| EMC Lab. | The Laboratory has been assessed and proved to be in compliance with CNAS/CL01: 2006(identical to ISO/IEC17025: 2005) The Certificate Registration Number is L0327 |
| | FCC Registration Number:435976; FCC Designation Number:CN1188 ISED Registration Number: 2055C; ISED Cab Identifier: CN0038 |
| Name of Firm | Intertek Testing Services Shenzhen Ltd. Longhua Branch |
| Site Location | 101, 201, Building B, No. 308 Wuhe Avenue, Zhangkengjing Community, GuanHu Subdistrict, LongHua District, ShenZhen, P.R. China |

6. Guidance Standard

The Specific Absorption Rate (SAR) testing specification, method, and procedure for this device is in accordance with the following standards:

- ☒ FCC 47CFR §2.1093 Radiofrequency Radiation Exposure Evaluation: Portable Devices
- ☒ NSI C95.1, 1992: Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz. (IEEE Std C95.1-1991)
- ☒ 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.
- ☒ KDB 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04: SAR Measurement Requirements for 100 MHz to 6 GHz
- ☒ KDB 865664 D02 SAR Reporting v01r02
- ☒ KDB 690783 D01 SAR Listings on Grants v01r03
- ☒ 447498 D04 Interim General RF Exposure Guidance v01
- ☒ KDB 941225 D06 Hotspot Mode v02r01: SAR Evaluation Procedures for Portable Devices with Wireless Router Capabilities
- ☒ KDB 248227 D01 802.11 Wi-Fi SAR v02r02: SAR Guidance for IEEE 802.11 (Wi-Fi) Transmitters
- ☒ KDB 616217 D04 SAR for laptop and tablets v01r02: SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers

Remark:

This portable wireless equipment has been measured in all cases requested by the relevant standards. Test results of this test report are below limits specified in the relevant standards for the tested bands only.

7. EUT Antenna Locations

Test position consideration:

| Distance of EUT antenna-to-edge/surface(mm), Test distance: 5cm | | | | | |
|--|------|------|-------|-----|--------|
| Front | Rear | Left | Right | Top | Bottom |
| Yes | Yes | Yes | Yes | Yes | Yes |
| <p>Note: SAR testing exemption according to KDB 447498 D04 Clause B.4 with the following formula.</p> $P_{th} \text{ (mW)} = \begin{cases} ERP_{20 \text{ cm}} (d/20 \text{ cm})^x & d \leq 20 \text{ cm} \\ ERP_{20 \text{ cm}} & 20 \text{ cm} < d \leq 40 \text{ cm} \end{cases}$ <p>where</p> $x = -\log_{10} \left(\frac{60}{ERP_{20 \text{ cm}} \sqrt{f}} \right)$ <p>and f is in GHz, d is the separation distance (cm), and $ERP_{20 \text{ cm}}$ is</p> $P_{th} \text{ (mW)} = ERP_{20 \text{ cm}} \text{ (mW)} = \begin{cases} 2040f & 0.3 \text{ GHz} \leq f < 1.5 \text{ GHz} \\ 3060 & 1.5 \text{ GHz} \leq f \leq 6 \text{ GHz} \end{cases}$ | | | | | |

8. RF Exposure

8.1 Limits

Uncontrolled Environment

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

Limits for General Population/Uncontrolled Exposure (W/kg)

| Whole-Body | Partial-Body | Hands, Wrists, Feet and ankles |
|------------|--------------|--------------------------------|
| 0.08 | 1.6 | 4.0 |

Whole-Body SAR is averaged over the entire body, partial-body SAR is averaged over any 1 gram of tissue defined as a tissue volume in the shape of a cube. SAR for hands, wrists, feet and ankles is averaged over any 10 grams of tissue defined as a tissue volume in the shape of a cube.

9. Specific Absorption Rate (SAR)

9.1 Introduction

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modelling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

9.2 SAR Definition

The SAR definition is 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 (ρ). 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 either related to the temperature elevation in tissue by

$$SAR = c \left(\frac{\delta T}{\delta t} \right)$$

Where: C is the specific heat capacity, δT is the temperature rise and δt is the exposure duration, or related to the electrical field in the tissue by

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

Where: σ is the conductivity of the tissue ρ is the mass density of tissue and E is the RMS electrical field strength.

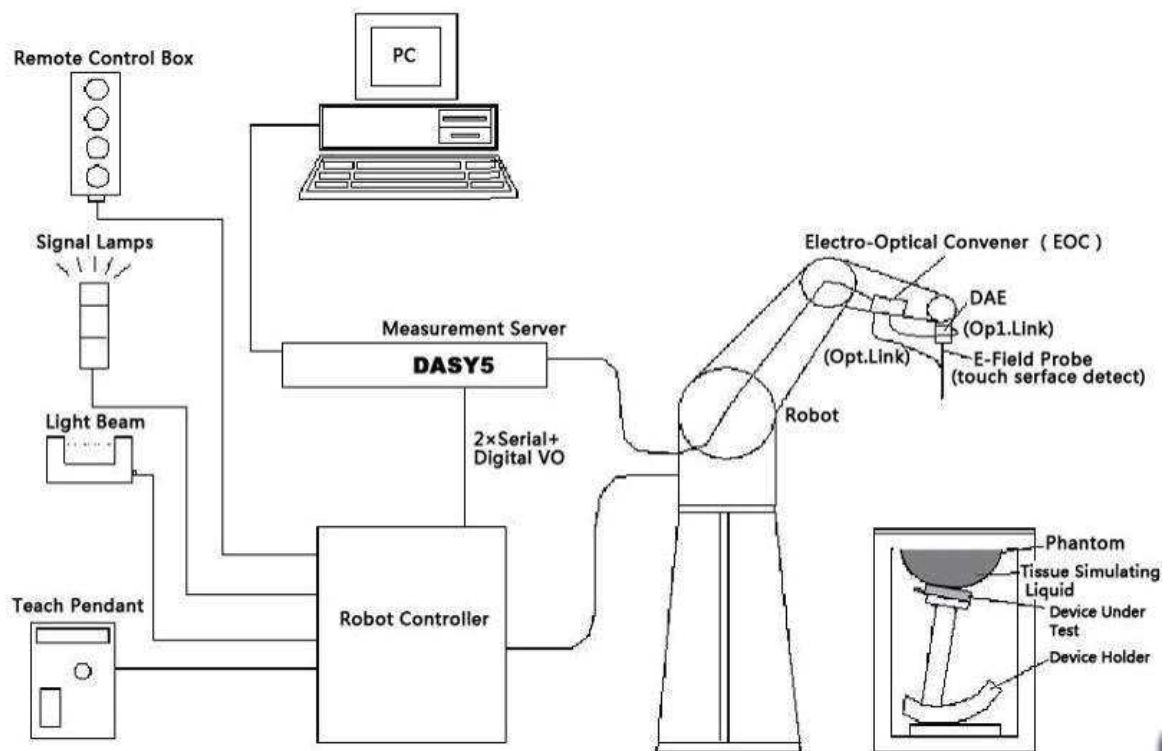
However, for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

10. SAR Measurements System Configuration

10.1 Sar Measurement Set-Up

The DASY5 system for performing compliance tests consists of the following items:

- A standard high precision 6-axis robot (Stäubli TX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- 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.
- 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.
- 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.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running Win 7 profesional operating system and the DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.



Picture 1: SAR Lab Test Measurement Set-up

10.2 DASY5 E-Field Probe System

The SAR measurements were conducted with the dosimetric probe designed in the classical triangular configuration 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 multifiber 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 DASY5 software reads the reflection turning a software approach and looks for the maximum using 2nd ord curve fitting. The approach is stopped at reaching the maximum.

Probe Specifications:

| | |
|-------------------|--|
| Model: | EX3DV4 |
| Calibration: | ISO/IEC 17025 calibration service available |
| Probe Length: | 337 mm |
| Probe Tip Length: | 9 mm |
| Body Diameter: | 10 mm |
| Tip Diameter: | 2.5 mm |
| Application: | High Precision dosimetric measurements in any exposure scenario (e.g., very strong Picture 2 E-field Probe gradient fields). |



Picture 2: E-field Probe

10.3 E-Field Probe Calibration

Each E-Probe/Probe Amplifier combination has unique calibration parameters. A TEM cell calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the probe to a known E-field density (1 mW/cm²) using an RF Signal generator, TEM cell, and RF Power Meter.

The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and in a waveguide or other methodologies above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees until the three channels show the maximum reading. The power density readings equate to 1 mW/cm².

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The E-field in the medium correlates with the temperature rise in the dielectric medium. For temperature correlation calibration a RF transparent thermistor-based temperature probe is used in conjunction with the E-field probe.

$$SAR = C \frac{\Delta T}{\Delta t}$$

Where:

Δt = Exposure time (30 seconds),

C = Heat capacity of tissue (brain or muscle),

ΔT = Temperature increase due to RF exposure.

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

Where:

σ = Simulated tissue conductivity,

ρ = Tissue density (kg/m³).

10.4 Other Test Equipment

10.4.1 Data Acquisition Electronics (DAE)

The data acquisition electronics consist of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder with a control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information, as well as an optical uplink for commands and the clock.

The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection.

The input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.



Picture 3: DAE

10.4.2 Robot

The SPEAG DASY system uses the high precision robots (DASY5: TX90XL) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability 0.02mm)
- High reliability (industrial design)
- Low maintenance costs (virtually maintenance free due to direct drive gears; no belt drives)
- Jerk-free straight movements (brushless synchron motors; no stepper motors)
- Low ELF interference (motor control fields shielded via the closed metallic construction shields)



Picture 4: DASY 5

10.4.3 Measurement Server

The Measurement server is based on a PC/104 CPU board with CPU (DASY5: 400 MHz, Intel Celeron), chip disk (DASY5: 128MB), RAM (DASY5: 128MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bit AD converter system for optical detection and digital I/O interface are contained on the DASY I/O board, which is directly connected to the PC/104 bus of the CPU board.



Picture 5: Server for DASY 5

The measurement server performs all real-time data evaluation of field measurements and surface detection, controls robot movements and handles safety operation. The PC operating system cannot interfere with these time critical processes. All connections are supervised by a watchdog, and disconnection of any of the cables to the measurement server will automatically disarm the robot and disable all program-controlled robot movements. Furthermore, the measurement server is equipped with an expansion port which is reserved for future applications. Please note that this expansion port does not have a standardized pinout, and therefore only devices provided by SPEAG can be connected. Devices from any other supplier could seriously damage the measurement server.

10.4.4 Device Holder for Phantom

The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source at 5mm distance, a positioning uncertainty of $\pm 0.5\text{mm}$ would produce a SAR uncertainty of $\pm 20\%$. Accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions in which the devices must be measured are defined by the standards.

The DASY device holder is designed to cope with the different positions given in the standard. It has two scales for device rotation (with respect to the body axis) and device inclination (with respect to the line between the ear reference points). The rotation centers for both scales are the ear reference point (ERP). Thus the device needs no repositioning when changing the angles.

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.

<Laptop Extension Kit>

The extension is lightweight and made of POM, acrylic glass and foam. It fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin-SAM and ELI phantoms.

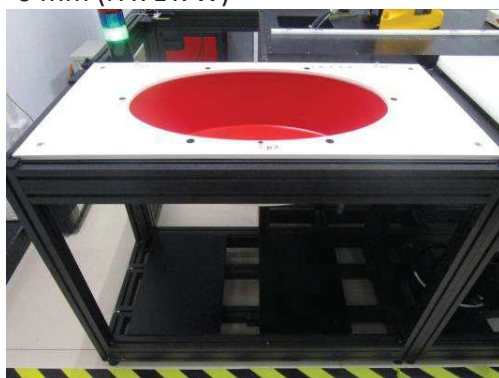


Picture 6: Device Holder

10.4.5 Phantom

Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is compatible with all SPEAG dosimetric probes and dipoles.

Shell Thickness: 2 ± 0.2 mm
Filling Volume: Approx. 30 liters
Dimensions: 190×600×0 mm (H x L x W)



Picture 7: ELI Phantom

10.5 Scanning Procedure

The DASY5 installation includes predefined files with recommended procedures for measurements and validation. They are read-only document files and destined as fully defined but unmeasured masks. All test positions (head or body-worn) are tested with the same configuration of test steps differing only in the grid definition for the different test positions.

The “reference” and “drift” measurements are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure. The indicated drift is mainly the variation of the DUT’s output power and should vary max. $\pm 5\%$.

The “surface check” measurement tests the optical surface detection system of the DASY5 system by repeatedly detecting the surface with the optical and mechanical surface detector and comparing the results. The output gives the detecting heights of both systems, the difference between the two systems and the standard deviation of the detection repeatability. Air bubbles or refraction in the liquid due to separation of the sugar-water mixture gives poor repeatability (above $\pm 0.1\text{mm}$). To prevent wrong results tests are only executed when the liquid is free of air bubbles. The difference between the optical surface detection and the actual surface depends on the probe and is specified with each probe. (It does not depend on the surface reflectivity or the probe angle to the surface within $\pm 30^\circ$.)

Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values before running a detailed measurement around the hot spot. Before starting the area scan a grid spacing is set according to FCC KDB Publication 865664. During scan the distance of the probe to the phantom remains unchanged. After finishing area scan, the field maxima within a range of 2 dB will be ascertained.

Zoom Scan

After the maximum interpolated values were calculated between the points in the cube, the SAR was averaged over the spatial volume (1g or 10g) using a 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines with the “Not a knot” condition (in x, y, and z directions). The volume was then integrated with the trapezoidal algorithm.

Spatial Peak Detection

The procedure for spatial peak SAR evaluation has been implemented and can determine values of masses of 1g and 10g, as well as for user-specific masses. The DASY5 system allows evaluations that combine measured data and robot positions, such as:

- maximum search
- extrapolation
- boundary correction
- peak search for averaged SAR

During a maximum search, global and local maxima searches are automatically performed in 2-D after each Area Scan measurement with at least 6 measurement points. It is based on the evaluation of the local SAR gradient calculated by the Quadratic Shepard’s method. The algorithm will find the global maximum and all local maxima within -2 dB of the global maxima for all SAR distributions.

Extrapolation routines are used to obtain SAR values between the lowest measurement points and the inner phantom surface. The extrapolation distance is determined by the surface detection distance and the probe sensor offset. Several measurements at different distances are necessary for the extrapolation. Extrapolation routines require at least 10 measurement points in 3-D space.

They are used in the Zoom Scan to obtain SAR values between the lowest measurement points and the inner phantom surface. The routine uses the modified Quadratic Shepard's method for extrapolation.

A Z-axis scan measures the total SAR value at the x-and y-position of the maximum SAR value found during the cube scan. The probe is moved away in z-direction from the bottom of the SAM phantom in 5mm steps.

Table 1: Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01

| Frequency | Maximum Area Scan Resolution (mm) (Δx_{area} , Δy_{area}) | Maximum Zoom Scan Resolution (mm) (Δx_{zoom} , Δy_{zoom}) | Maximum Zoom Scan Spatial Resolution (mm) $\Delta z_{zoom}(n)$ | Minimum Zoom Scan Volume (mm) (x,y,z) |
|--------------|--|--|---|--|
| ≤ 2 GHz | ≤ 15 | ≤ 8 | ≤ 5 | ≥ 30 |
| 2-3 GHz | ≤ 12 | ≤ 5 | ≤ 5 | ≥ 30 |
| 3-4 GHz | ≤ 12 | ≤ 5 | ≤ 4 | ≥ 28 |
| 4-5 GHz | ≤ 10 | ≤ 4 | ≤ 3 | ≥ 25 |
| 5-6 GHz | ≤ 10 | ≤ 4 | ≤ 2 | ≥ 22 |

10.6 Data Storage and Evaluation

10.6.1 Data Storage

The DASY5 software stores the acquired data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files with the extension ".DAE4". The software evaluates the desired unit and format for output each time the data is visualized or exported. This allows verification of the complete software setup even after the measurement and allows correction of incorrect parameter settings. For example, if a measurement has been performed with a wrong crest factor parameter in the device set up, the parameter can be corrected afterwards and the data can be re-evaluated.

The measured data can be visualized or exported in different units or formats, depending on the selected probe type ([V/m], [A/m], [°C], [mW/g], [mW/cm²], [dBrel], etc.). Some of these units are not available in certain situations or show meaningless results, e.g., a SAR output in a loss less media will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

10.6.2 Data Evaluation by SEMCAD

The SEMCAD software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The parameters used in the evaluation are stored in the configuration modules of the software:

Probe parameters:

- Sensitivity Norm_i, a_{i0}, a_{i1}, a_{i2}
- Conversion factor ConvF_i
- Diode compression point Dcp_i

Device parameters:

- Frequency f
- Crest factor cf

Media parameters:

- Conductivity
- Density

These parameters must be set correctly in the software. They can be found in the component documents or they can be imported into the software from the configuration files issued for the DASY5 components. In the direct measuring mode of the multimeter option, the parameters of the actual system setup are used. In the scan visualization and export modes, the parameters stored in the corresponding document files are used.

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics.

If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given as:

$$V_i = U_i + U_i^2 \cdot c \cdot f / dcp_i$$

With V_i = compensated signal of channel i (i = x, y, z)

U_i = input signal of channel i (i = x, y, z)

cf = crest factor of exciting field (DASY parameter)

dcp_i = diode compression point (DASY parameter)

From the compensated input signals the primary field data for each channel can be evaluated:

E-field probes: $E_i = (V_i / Norm_i \cdot ConvF)^{1/2}$

H-field probes: $H_i = (V_i)^{1/2} \cdot (a_{i0} + a_{i1} f + a_{i2} f^2) / f$

With V_i = compensated signal of channel i (i = x, y, z)

Norm_i = sensor sensitivity of channel i (i = x, y, z)

[mV/(V/m)²] for E-field Probes

ConvF = sensitivity enhancement in solution

a_{ij} = sensor sensitivity factors for H-field probes

f = carrier frequency [GHz]

E_i = electric field strength of channel i in V/m

H_i = magnetic field strength of channel i in A/m

The RSS value of the field components gives the total field strength (Hermitian magnitude):

$$E_{tot} = (E_x^2 + E_y^2 + E_z^2)^{1/2}$$

The primary field data are used to calculate the derived field units.

$$\text{SAR} = (\text{E}_{\text{tot}})^2 \cdot \sigma / (\rho \cdot 1000)$$

with **SAR** = local specific absorption rate in mW/g

E_{tot} = total field strength in V/m

σ = conductivity in [mho/m] or [Siemens/m]

ρ = equivalent tissue density in g/cm³

Note that the density is normally set to 1 (or 1.06), to account for actual brain density rather than the density of the simulation liquid. The power flow density is calculated assuming the excitation field to be a free space field.

$$\text{P}_{\text{pwe}} = \text{E}_{\text{tot}}^2 / 3770 \text{ or } \text{P}_{\text{pwe}} = \text{H}_{\text{tot}}^2 \cdot 37.7$$

with **P_{pwe}** = equivalent power density of a plane wave in mW/cm²

E_{tot} = total electric field strength in V/m ; **H_{tot}** = total magnetic field strength in A/m

10.7 Tissue-Equivalent Liquid

10.7.1 Tissue-equivalent Liquid Ingredients

The liquid is consisted of water, salt and Glycol. The liquid has previously been proven to be suited for worst-case. The Table 2 & 3 shows the detail solution. It's satisfying the latest tissue dielectric parameters requirements proposed by the KDB 865664 D01.

Table 2: Recommended Dielectric Performance of Tissue

| MIXTURE (%) | FREQUENCY (Head) 2450MHz |
|------------------------------------|-------------------------------|
| Water | 55 |
| TWEEN | 45 |
| Dielectric Parameters Target Value | f=2450MHz ε=39.2 σ=1.80 |

10.7.2 Tissue-equivalent Liquid Properties

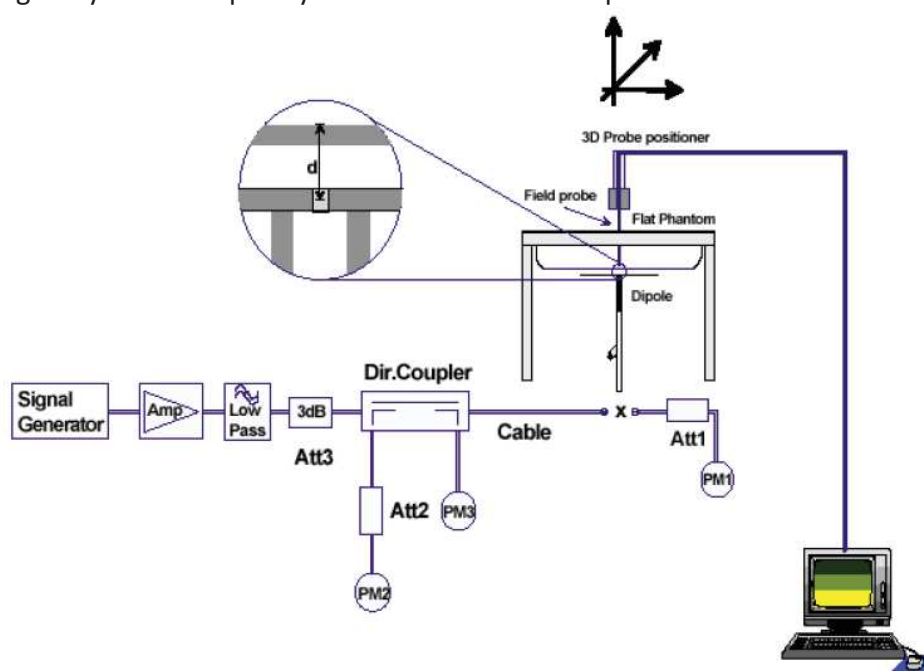
Table 3: Dielectric Performance of Head Tissue Simulating Liquid

| Temperature: 21°C Relative humidity: 57% | | | | |
|--|---------------|-------------------|-----------------------|---------------|
| Frequency (MHz) | Measured Date | Description | Dielectric Parameters | |
| | | | ϵ_r | $\sigma(s/m)$ |
| 2450 | 2025-02-21 | Target Value | 39.2 | 1.80 |
| | | $\pm 5\%$ window | 37.24 — 41.16 | 1.71 — 1.89 |
| | | Measurement Value | 38.25 | 1.88 |

10.8 System Check

10.8.1 Description of System Check

The manufacturer calibrates the probes annually. Dielectric parameters of the tissue simulants were measured every day using the dielectric probe kit and the network analyzer. A system check measurement was made following the determination of the dielectric parameters of the simulant, using the dipole validation kit. A power level of 250 mW was supplied to the dipole antenna, which was placed under the flat section of the twin SAM phantom. The system check results (dielectric parameters and SAR values) are given in the table 5. System check results have to be equal or near the values determined during dipole calibration with the relevant liquids and test system ($\pm 10\%$). System check is performed regularly on all frequency bands where tests are performed with the DASY5 system.



Picture 8: system Check Set-up

Justification for Extended SAR Dipole Calibrations

Usage of SAR dipoles calibrated less than 3 years ago but more than 1 year ago were confirmed in maintaining return loss (< -20 dB, within 20% of prior calibration) and impedance (within 5 ohm from prior calibration) requirements per extended calibrations in KDB 865664 D01:

10.8.2 System Check Results

Table 5: System Check for Simulating Liquid

| Measurement Date | Frequency (MHz) | Liquid Type (head/body) | 1W Target SAR1g (W/kg) | Measured SAR1g (W/kg) | 1W Normalized SAR1g (W/kg) | Limit (±10% Deviation) |
|------------------|-----------------|-------------------------|------------------------|-----------------------|----------------------------|------------------------|
| 2025-02-21 | 2450 | Head | 52.5 | 13.2 | 52.8 | 0.57 |

Note:

For 2450MHz system check input power: 250mW

11. Measurement Procedures

11.1 General Description of Test Procedures

For WLAN SAR testing, WLAN engineering testing software installed on the DUT can provide continuous transmitting RF signal. This RF signal utilized in SAR measurement has almost 100% duty cycle and its crest factor is 1.

For the 802.11a/b/g/n SAR tests, a communication link is set up with the test mode software for WIFI mode test. During the test, at the each test frequency channel, the EUT is operated at the RF continuous emission mode. Provided higher maximum output power is not specified for the other channels, channels 1, 6, 11 are used to configure 22 MHz DSSS and 20MHz OFDM channels for SAR measurements; otherwise, the closest adjacent channel with the highest maximum output power specified for production units should be tested instead of channels 1, 6, 11. In addition, SAR test reduction with respect to reported SAR and transmission band width according to 4.3.3 of KDB Publication 447498 D01 may also be applied.

802.11a/b/g/n operating modes are tested independently according to the service requirements in each frequency band. 802.11b/g/n modes are tested on the maximum average output channel.

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 (see 3.1) for the exposure configuration is ≤ 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.

When SAR measurement is required for 2.4 GHz 802.11g/n OFDM configurations, the measurement and test reduction procedures for OFDM are applied (see 11.1.2, including subclauses). SAR is not required for the following 2.4 GHz OFDM conditions.

- a) When KDB Publication 447498 D04 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 ≤ 1.2 W/kg.

11.2 Measurement Variability

Per FCC KDB Publication 865664 D01, SAR measurement variability was assessed for each frequency band, which was determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media were required for SAR measurements in a frequency band, the variability measurement procedures were applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium. These additional measurements were repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device was returned to ambient conditions (normal room temperature) with the battery fully charged before it was re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

SAR Measurement Variability was assessed using the following procedures for each frequency band:

1. Repeated measurement is not required when the original highest measured SAR is < 2.00 W/kg; steps 2) through 4) do not apply.
2. When the original highest measured SAR is ≥ 2.00 W/kg, repeat that measurement once.
3. Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 3.0 or when the original or repeated measurement is ≥ 3.625 W/kg ($\sim 10\%$ from the 1-g SAR limit).
4. Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 3.75 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 3.0 .

12. Test Results

12.1 Conducted Power Results

Test Condition:

1. Conducted Measurement

EUT was set for low, mid, high channel with modulated mode and highest RF output power.
The base station simulator was connected to the antenna terminal.

2 Conducted Emissions Measurement Uncertainty

All test measurements carried out are traceable to national standards. The uncertainty of the measurement at a confidence level of approximately 95% (in the case where distributions are normal), with a coverage factor of 2, in the range 30MHz – 40GHz is $\pm 1.5\text{dB}$.

| | | | |
|---|--------------------------|----------------------|----------|
| 3 | Environmental Conditions | Temperature | 22°C |
| | | Relative Humidity | 55% |
| | | Atmospheric Pressure | 1009mbar |

4 Test Date: 21 February 2025 to 26 February 2025

Test Procedures:

The output power was measured using power meter at low, mid, and hi channels.

Operating Rang: 2.4GHz

| Mode | Channel number | Frequency (MHz) | Data rate (Mbps) | Average Output Power (dBm) | Average Tune up limited (dBm) |
|---------------|----------------|-----------------|------------------|----------------------------|-------------------------------|
| 802.11b | 1 | 2412 | 1 | 18.35 | 18.0 \pm 1 |
| | 6 | 2437 | 1 | 18.31 | 18.0 \pm 1 |
| | 11 | 2462 | 1 | 18.41 | 18.0 \pm 1 |
| 802.11g | 1 | 2412 | 6 | 18.07 | 18.0 \pm 1 |
| | 6 | 2437 | 6 | 18.43 | 18.0 \pm 1 |
| | 11 | 2462 | 6 | 17.98 | 18.0 \pm 1 |
| 802.11n(HT20) | 1 | 2412 | MCS0 | 17.97 | 18.0 \pm 1 |
| | 6 | 2437 | MCS0 | 18.18 | 18.0 \pm 1 |
| | 11 | 2462 | MCS0 | 18.48 | 18.0 \pm 1 |

| Mode | Channel number | Frequency (MHz) | Data rate (Mbps) | Average Output Power (dBm) | Average Tune up limited (dBm) |
|--------|----------------|-----------------|------------------|----------------------------|-------------------------------|
| BLE 1M | 0 | 2402 | 1 | 5.02 | 5.0 \pm 1 |
| | 19 | 2440 | 1 | 4.86 | 5.0 \pm 1 |
| | 39 | 2480 | 1 | 4.69 | 5.0 \pm 1 |
| BLE 2M | 0 | 2402 | 2 | 5.25 | 5.0 \pm 1 |
| | 19 | 2440 | 2 | 5.06 | 5.0 \pm 1 |
| | 39 | 2480 | 2 | 4.86 | 5.0 \pm 1 |

12.2 SAR Test Results

Table 6: SAR Values

| Test Mode | Test Position | Channel / Frequency (MHz) | Modulation Mode | Maximum Allowed Power (dBm) | Conducted Power (dBm) | Drift ±0.21 dB | Limit SAR _{1g} 1.6 W/kg | | |
|-------------------|--|---------------------------|-----------------|-----------------------------|-----------------------|----------------|-----------------------------------|----------------|-----------------------------------|
| | | | | | | | Measured SAR _{1g} (W/kg) | Scaling Factor | Reported SAR _{1g} (W/kg) |
| | Test Position of extremity (Distance Between EUT and Flat Phantom 5cm) | | | | | | | | |
| 2.4g WIFI 802.11B | Front Side | 11/2462 | DSSS | 19.0 | 18.41 | 0.06 | 0.0176 | 1.15 | 0.020 |
| | Rear Side | 11/2462 | DSSS | 19.0 | 18.41 | 0.12 | 0.0129 | 1.15 | 0.015 |
| | Left Side | 11/2462 | DSSS | 19.0 | 18.41 | 0.12 | 0.00265 | 1.15 | 0.003 |
| | Right Side | 11/2462 | DSSS | 19.0 | 18.41 | -0.02 | 0.00242 | 1.15 | 0.003 |
| | Top Side | 11/2462 | DSSS | 19.0 | 18.41 | 0.16 | 0.00655 | 1.15 | 0.008 |
| | Bottom Side | 11/2462 | DSSS | 19.0 | 18.41 | 0.05 | 0.00114 | 1.15 | 0.001 |
| BLE | Front Side | 0/2402 | 2M | 6.0 | 5.25 | 0.00 | 0.00498 | 1.19 | 0.006 |
| | Rear Side | 0/2402 | 2M | 6.0 | 5.25 | 0.01 | 0.00397 | 1.19 | 0.005 |
| | Left Side | 0/2402 | 2M | 6.0 | 5.25 | 0.02 | 0.00058 | 1.19 | 0.001 |
| | Right Side | 0/2402 | 2M | 6.0 | 5.25 | 0.03 | 0.00068 | 1.19 | 0.001 |
| | Top Side | 0/2402 | 2M | 6.0 | 5.25 | 0.05 | 0.00069 | 1.19 | 0.001 |
| | <p>Note:</p> <p>1. When the reported SAR of the highest measured maximum output power channel for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.</p> <p>2. 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.</p> <p>3. The EUT exercise program (provided by client) used during SAR testing was designed to exercise the various system components in a manner similar to a typical use. During the test, Channel and test mode software provided by the applicant was used to control the operating channel as well as the test mode. The worst case configuration is used in all specified testing.</p> | | | | | | | | |

Table 7: 2.4 GHz OFDM SAR Test Exclusion Requirements

| Test Position | Channel/ Frequency (MHz) | 802.11b Max. Allowed Power (dBm) | 802.11g/n Max. Allowed Power (dBm) | Limit SAR _{1g} : 1.6W/kg | | |
|--|--------------------------|----------------------------------|------------------------------------|---|----------------|-----------------------------------|
| | | | | 802.11b Report SAR _{1g} (W/kg) | Scaling Factor | Adjusted SAR _{1g} (W/kg) |
| Front Side | 11/2462 | 19.0 | 19.0 | 0.020 | 1.00 | 0.020 |
| Note: SAR is not required for the 2.4 GHz OFDM conditions if 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 ≤ 1.2 W/kg. | | | | | | |

12.3 Maximum Graph Results

The graph results see ANNEX C.

13. Measurement Uncertainty

When the highest measured 1-g SAR within a frequency band is < 1.5 W/kg, the extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval.

14. Main Test Instrument

| Equipment No. | Equipment | Manufacturer | Model No. | Serial No. | Last Cal. | Cal. Interval |
|---------------|-----------------------------|------------------------------|-------------------|-----------------|------------|---------------|
| SZ060-01 | SAR Test System | SPEAG | DASY52 SAR TX90XL | F14/5YJ0B1/A/01 | 2024-03-18 | 1 year |
| SZ060-01-01 | E-Field Probe | SPEAG | EX3DV4 | 7322 | 2024-03-26 | 1 year |
| SZ060-01-10 | System Validation Dipole | SPEAG | D2450V2 | 966 | 2024-11-06 | 3 year |
| SZ060-01-13 | Data Acquisition Unit | SPEAG | DAE4 | 1473 | 2024-03-18 | 1 year |
| SZ060-01-14 | Dielectric Assessment Kit | SPEAG | DAKS 3.5 | 1056 | N/A | N/A |
| SZ060-01-15 | Vector Reflectometer | Copper Mountain Technologies | Planar R140 | 0090614 | N/A | N/A |
| SZ060-01-16 | Thermometer | LKM electronics GmbH | DTM3000 | 3477 | 2024-12-26 | 1 year |
| SZ060-01-17 | Power Amplifier | Mini Circuits | ZHL-42W+ | QA1449003 | 2024-04-01 | 1 year |
| SZ060-01-18 | Power Amplifier | Mini Circuits | ZVE-8G+ | 111701437 | 2024-04-01 | 1 year |
| SZ060-01-21 | ELI Phantom | SPEAG | ELI Phantom V6.0 | 2033 | N/A | N/A |
| SZ180-13 | MXG Vector Signal Generator | Keysight | N5182B | MY53051328 | 2024-09-29 | 1 year |
| SZ070-04 | Directional Bridge | Agilent | 86205A | MY31402141 | 2024-12-05 | 1 year |
| SZ182-02 | RF Power Meter | Anritsu | ML2496A | 1302005 | 2024-04-22 | 1 year |
| SZ182-03 | Average power sensor | R&S | NRP-Z22 | 101689 | 2024-04-22 | 1 year |
| N/A | Device Holder | SPEAG | N/A | N/A | N/A | N/A |

ANNEX A: Test Layout and Setup

Please refer to the Document of Test Layout and Setup.

ANNEX B: System Check Results

Date: 2/21/2025

Test Laboratory: Intertek Service

System Check H2450

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

Medium: Head Medium parameters used: $f = 2450$ MHz; $\sigma = 1.882$ S/m; $\epsilon_r = 38.25$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Ambient Temperature: 22.0 °C; Liquid Temperature: 21.5 °C

DASY Configuration:

- Probe: EX3DV4 - SN7322; ConvF(7.36, 7.36, 7.36) @ 2450 MHz; Calibrated: 3/26/2024
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1473; Calibrated: 3/18/2024
- Phantom: ELI V6.0 (20deg probe tilt); Type: QD OVA 003 AA; Serial: 2033
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Configuration/Pin=250 mW/Area Scan (7x11x1): Measurement grid: dx=12mm, dy=12mm

Maximum value of SAR (measured) = 16.3 W/kg

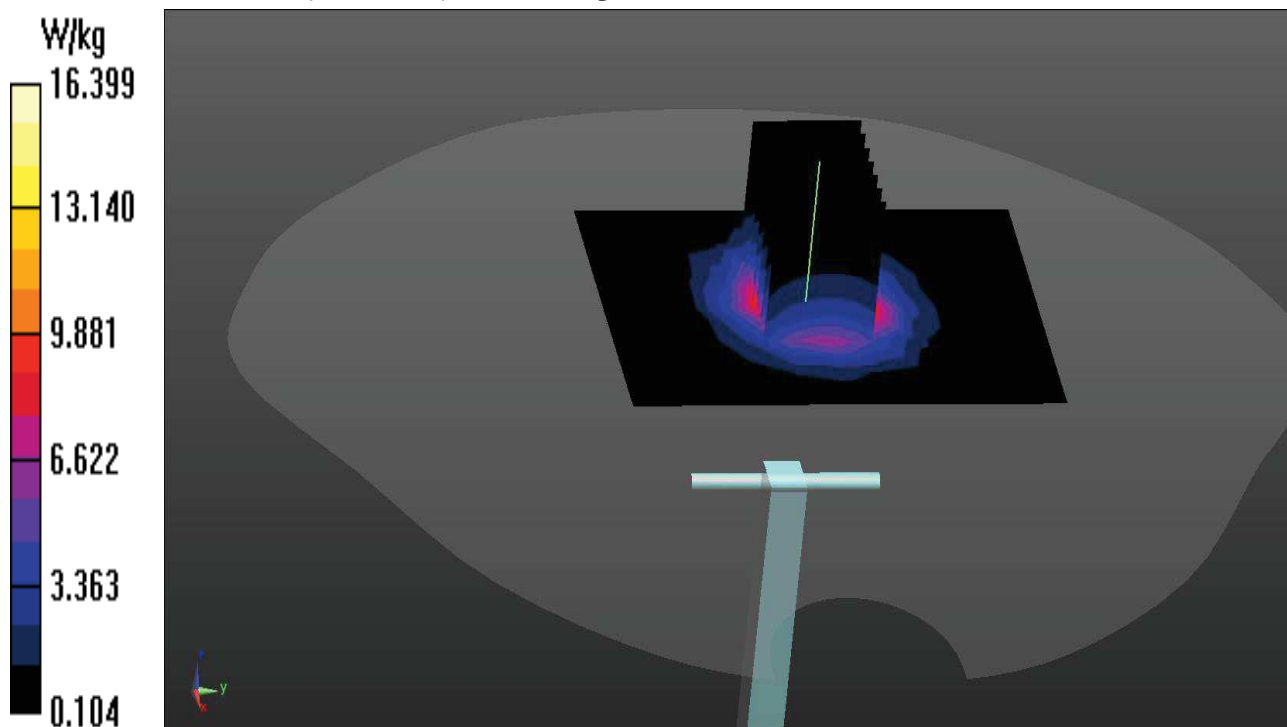
Configuration/Pin=250 mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 93.25 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 25.8 W/kg

SAR(1 g) = 12.9 W/kg; SAR(10 g) = 6.11 W/kg

Maximum value of SAR (measured) = 16.4 W/kg



ANNEX C: Maximum Graph Results

Date: 2/21/2025

Test Laboratory: Intertek Service

WIFI b_Front Side_CH11

Communication System: UID 0, WIFI 11B(DSSS 1Mbps 99pc duty cycle) (0); Frequency: 2462 MHz; Duty Cycle: 1:1.42561

Medium: 2450 Head Medium parameters used: $f = 2462$ MHz; $\sigma = 1.896$ S/m; $\epsilon_r = 38.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Ambient Temperature: 22.0 °C; Liquid Temperature: 21.5 °C

DASY Configuration:

- Probe: EX3DV4 - SN7322; ConvF(7.36, 7.36, 7.36) @ 2462 MHz; Calibrated: 3/26/2024
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1473; Calibrated: 3/18/2024
- Phantom: SAM 1 V5.0 (30deg); Type: QD 000 P40 CD; Serial: 1888
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Area Scan (14x14x1): Measurement grid: dx=12mm, dy=12mm

Maximum value of SAR (measured) = 0.0275 W/kg

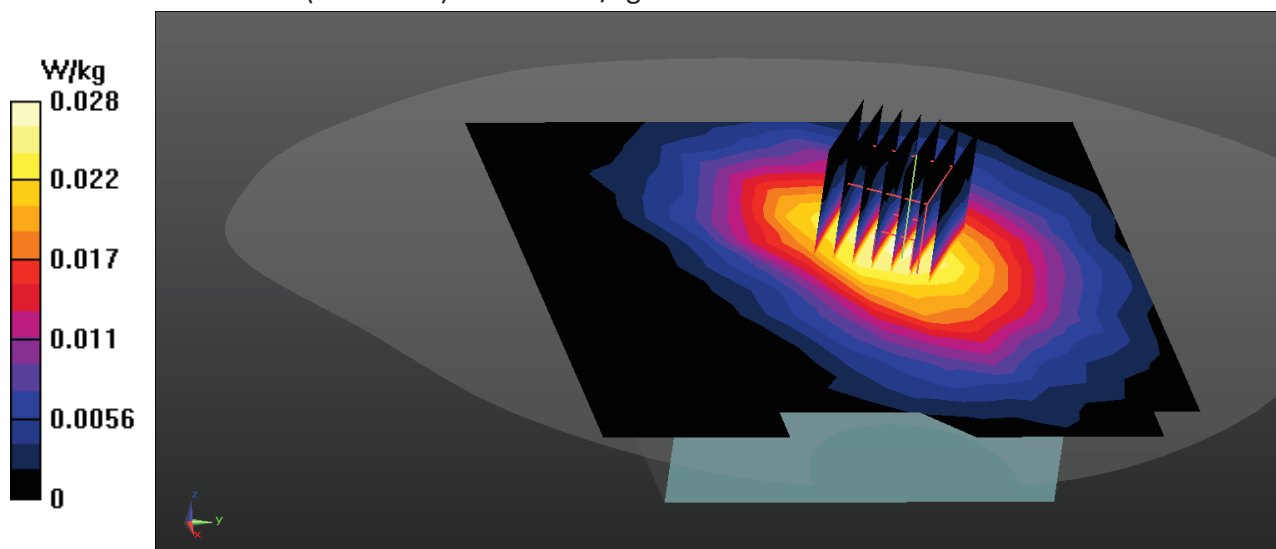
Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 3.034 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 0.0350 W/kg

SAR(1 g) = 0.018 W/kg; SAR(10 g) = 0.00965 W/kg

Maximum value of SAR (measured) = 0.0280 W/kg



Test Laboratory: Intertek Service

BLE_Front Side_CHO

Communication System: UID 0, WIFI 11B(DSSS 1Mbps 99pc duty cycle) (0); Frequency: 2462 MHz; Duty Cycle: 1:1.42561

Medium: 2450 Head Medium parameters used: $f = 2462$ MHz; $\sigma = 1.896$ S/m; $\epsilon_r = 38.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Ambient Temperature: 22.0 °C; Liquid Temperature: 21.5 °C

DASY Configuration:

- Probe: EX3DV4 - SN7322; ConvF(7.36, 7.36, 7.36) @ 2462 MHz; Calibrated: 3/26/2024
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1473; Calibrated: 3/18/2024
- Phantom: SAM 1 V5.0 (30deg); Type: QD 000 P40 CD; Serial: 1888
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Area Scan (14x14x1): Measurement grid: dx=12mm, dy=12mm

Maximum value of SAR (measured) = 0.0293 W/kg

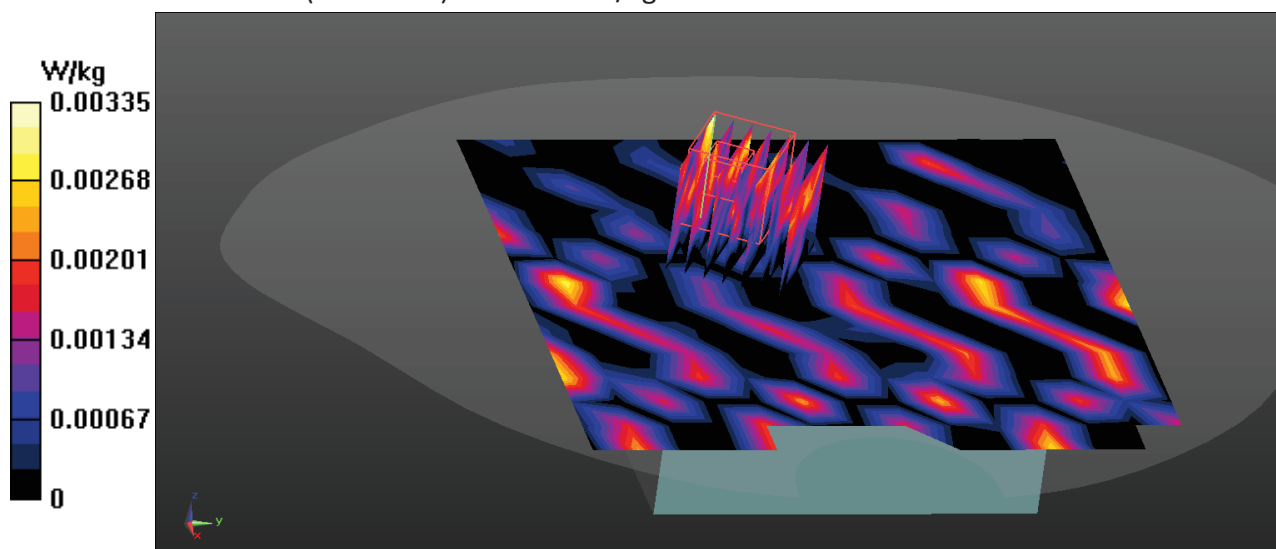
Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 0 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 0.00532 W/kg

SAR(1 g) = 0.00498 W/kg; SAR(10 g) = 0.00163 W/kg

Maximum value of SAR (measured) = 0.00335 W/kg



ANNEX D: System Validation

The SAR system must be validated against its performance specifications before it is deployed. When SAR probes, system components or software are changed, upgraded or recalibrated, these must be validated with the SAR system(s) that operates with such components.

Justification for Extended SAR Dipole Calibrations

Usage of SAR dipoles calibrated less than 3 years ago but more than 1 year ago were confirmed in maintaining return loss (≤ 20 dB, within 20% of prior calibration) and impedance (within 5 ohm from prior calibration) requirements per extended calibrations in KDB 865664 D01:

Table D.1: Antenna Parameters with Head Tissue Simulating Liquid

Table D.1: System Validation Part 1

| Dipole D2450V2 SN: 966 | | | | |
|------------------------|-----------------|------------|------------------------|----------------|
| Head Liquid | | | | |
| Date of Measurement | Return Loss(dB) | Δ % | Impedance (Ω) | $\Delta\Omega$ |
| 2024-11-06 | -27.0 | / | 51.5+4.27j | / |

Table D.2: System Validation Part 2

| System No. | Probe SN. | Liquid name | Validation date | Frequency point | Permittivity ϵ | Conductivity σ (S/m) |
|------------|-----------|-------------|-----------------|-----------------|-------------------------|-----------------------------|
| 1 | 966 | Head | 2025-02-21 | 2450MHz | 38.25 | 1.88 |

Table D.3: System Validation Part 3

| CW Validation | Sensitivity | PASS | PASS |
|-----------------|-----------------|------|------|
| | Probe linearity | PASS | PASS |
| | Probe Isotropy | PASS | PASS |
| Mod. Validation | MOD.type | QPSK | QPSK |
| | Duty factor | PASS | PASS |
| | PAR | PASS | PASS |

ANNEX E: Probe, DAE and Dipole Calibration Certificate



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中国认可
国际互认
校准
CALIBRATION
CNAS L0570

Client **Intertek**

Certificate No: **24J02Z000079**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN : 7322**

Calibration Procedure(s) **FF-Z11-004-02**
Calibration Procedures for Dosimetric E-field Probes

Calibration date: **March 26, 2024**

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 | 12-Jun-23(CTTL, No.J23X05435) | Jun-24 |
| Power sensor NRP-Z91 | 101547 | 12-Jun-23(CTTL, No.J23X05435) | Jun-24 |
| Power sensor NRP-Z91 | 101548 | 12-Jun-23(CTTL, No.J23X05435) | Jun-24 |
| Reference 10dBAttenuator | 18N50W-10dB | 19-Jan-23(CTTL, No.J23X00212) | Jan-25 |
| Reference 20dBAttenuator | 18N50W-20dB | 19-Jan-23(CTTL, No.J23X00211) | Jan-25 |
| Reference Probe EX3DV4 | SN 3846 | 31-May-23(SPEAG, No.EX-3846_May23) | May-24 |
| DAE4 | SN 1555 | 24-Aug-23(SPEAG, No.DAE4-1555_Aug23) | Aug-24 |
| Secondary Standards | ID # | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
| SignalGenerator MG3700A | 6201052605 | 12-Jun-23(CTTL, No.J23X05434) | Jun-24 |
| Network Analyzer E5071C | MY46110673 | 25-Dec-23(CTTL, No.J23X13425) | Dec-24 |
| Reference 10dBAttenuator | BT0520 | 11-May-23(CTTL, No.J23X04061) | May-25 |
| Reference 20dBAttenuator | BT0267 | 11-May-23(CTTL, No.J23X04062) | May-25 |
| OCP DAK-12 | SN 1174 | 25-Oct-23(SPEAG, No.OCP-DAK12-1174_Oct23) | Oct-24 |

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

Issued: March 29, 2024

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



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Glossary:

| | |
|-----------------------|---|
| TSL | tissue simulating liquid |
| NORM _{x,y,z} | sensitivity in free space |
| ConvF | sensitivity in TSL / NORM _{x,y,z} |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A,B,C,D | modulation dependent linearization parameters |
| Polarization Φ | Φ rotation around probe axis |
| Polarization θ | θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i $\theta=0$ 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_{x,y,z}:** Assessed for E-field polarization $\theta=0$ ($f \leq 900\text{MHz}$ in TEM-cell; $f > 1800\text{MHz}$: waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not effect the E^2 -field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z} = NORM_{x,y,z} * 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_{x,y,z}:** 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_{x,y,z}; B_{x,y,z}; C_{x,y,z}; VR_{x,y,z}:** 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_{x,y,z} 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_x (no uncertainty required).



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DASY/EASY – Parameters of Probe: EX3DV4 – SN:7322

Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc ($k=2$) |
|--------------------------------------|----------|----------|----------|---------------|
| Norm($\mu V/(V/m)^2$) ^A | 0.46 | 0.57 | 0.54 | $\pm 10.0\%$ |
| DCP(mV) ^B | 98.7 | 97.4 | 100.9 | |

Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB $\sqrt{\mu V}$ | C | D dB | VR mV | Unc ^E ($k=2$) |
|-----|---------------------------|---|------|---------------------|-----|------|-------|----------------------------|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 159.1 | $\pm 2.2\%$ |
| | | Y | 0.0 | 0.0 | 1.0 | | 177.9 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 176.2 | |

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%.

^A The uncertainties of Norm X, Y, Z do not affect the E²-field uncertainty inside TSL (see Page 4).

^B Numerical linearization parameter: uncertainty not required.

^E Uncertainty 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:7322

Calibration Parameter Determined in Head Tissue Simulating Media

| f [MHz] ^C | Relative Permittivity ^F | Conductivity (S/m) ^F | ConvF X | ConvF Y | ConvF Z | Alpha ^G | Depth ^G (mm) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 750 | 41.9 | 0.89 | 10.03 | 10.03 | 10.03 | 0.14 | 1.31 | ± 12.7% |
| 835 | 41.5 | 0.90 | 9.65 | 9.65 | 9.65 | 0.11 | 1.59 | ± 12.7% |
| 1750 | 40.1 | 1.37 | 8.30 | 8.30 | 8.30 | 0.23 | 1.06 | ± 12.7% |
| 1900 | 40.0 | 1.40 | 7.96 | 7.96 | 7.96 | 0.27 | 0.99 | ± 12.7% |
| 2300 | 39.5 | 1.67 | 7.64 | 7.64 | 7.64 | 0.65 | 0.65 | ± 12.7% |
| 2450 | 39.2 | 1.80 | 7.36 | 7.36 | 7.36 | 0.60 | 0.69 | ± 12.7% |
| 2600 | 39.0 | 1.96 | 7.10 | 7.10 | 7.10 | 0.41 | 0.90 | ± 12.7% |
| 5250 | 35.9 | 4.71 | 5.25 | 5.25 | 5.25 | 0.45 | 1.40 | ± 13.9% |
| 5600 | 35.5 | 5.07 | 4.65 | 4.65 | 4.65 | 0.55 | 1.20 | ± 13.9% |
| 5750 | 35.4 | 5.22 | 4.80 | 4.80 | 4.80 | 0.50 | 1.30 | ± 13.9% |

^C 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.

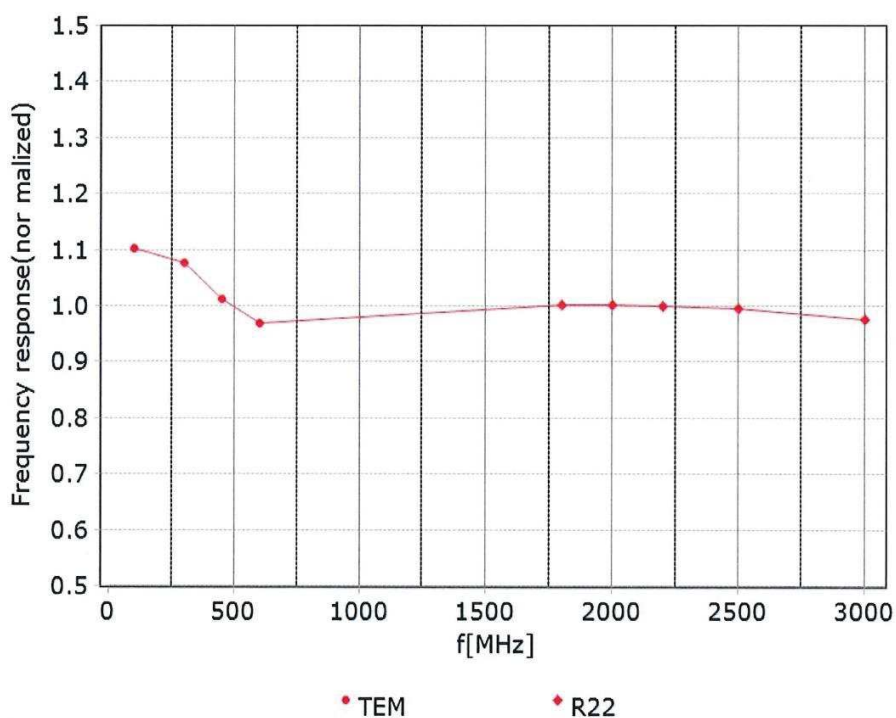
^F At frequency up to 6 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G 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.



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



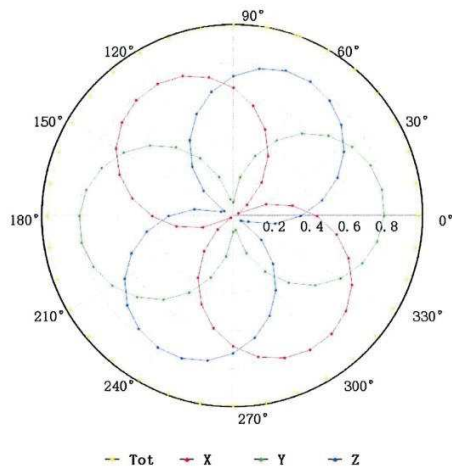
Uncertainty of Frequency Response of E-field: $\pm 7.4\%$ ($k=2$)



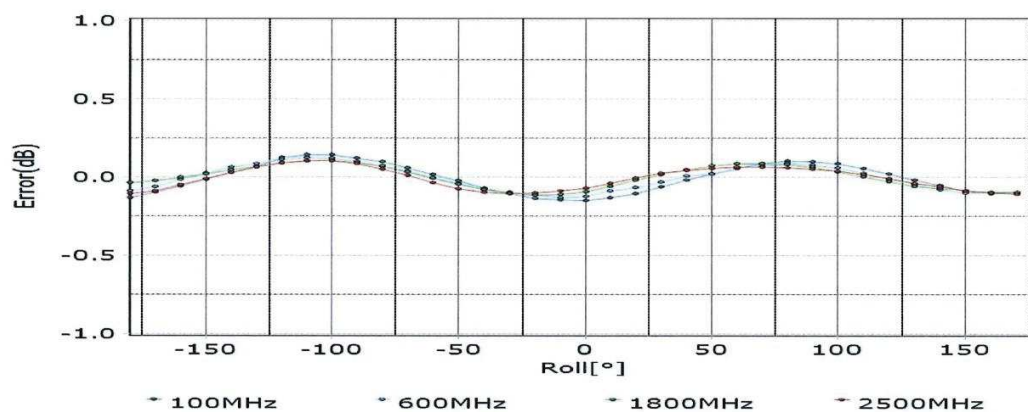
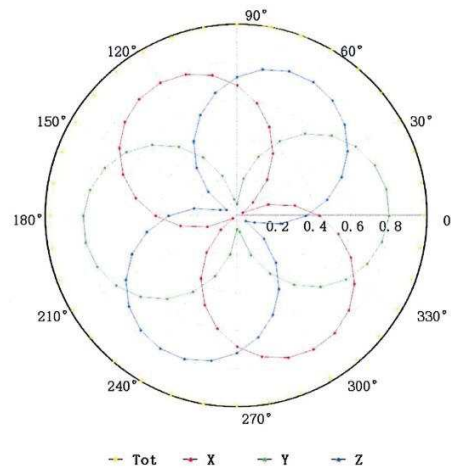
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Receiving Pattern (Φ), $\theta=0^\circ$

f=600 MHz, TEM



f=1800 MHz, R22

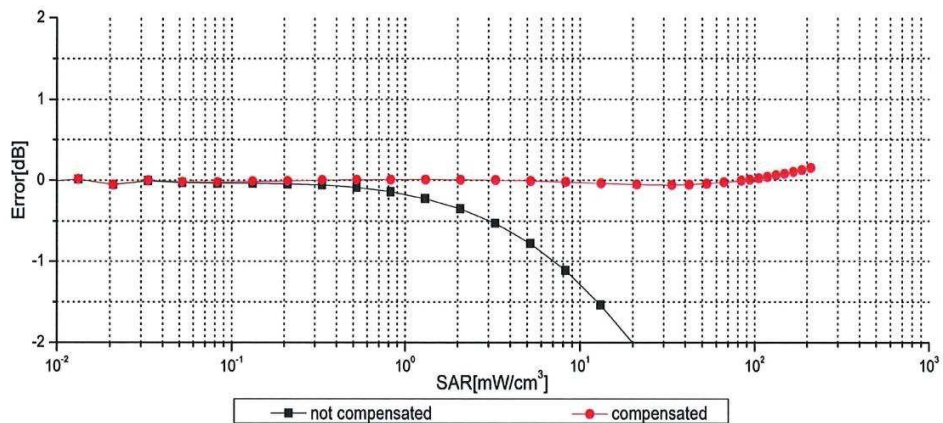
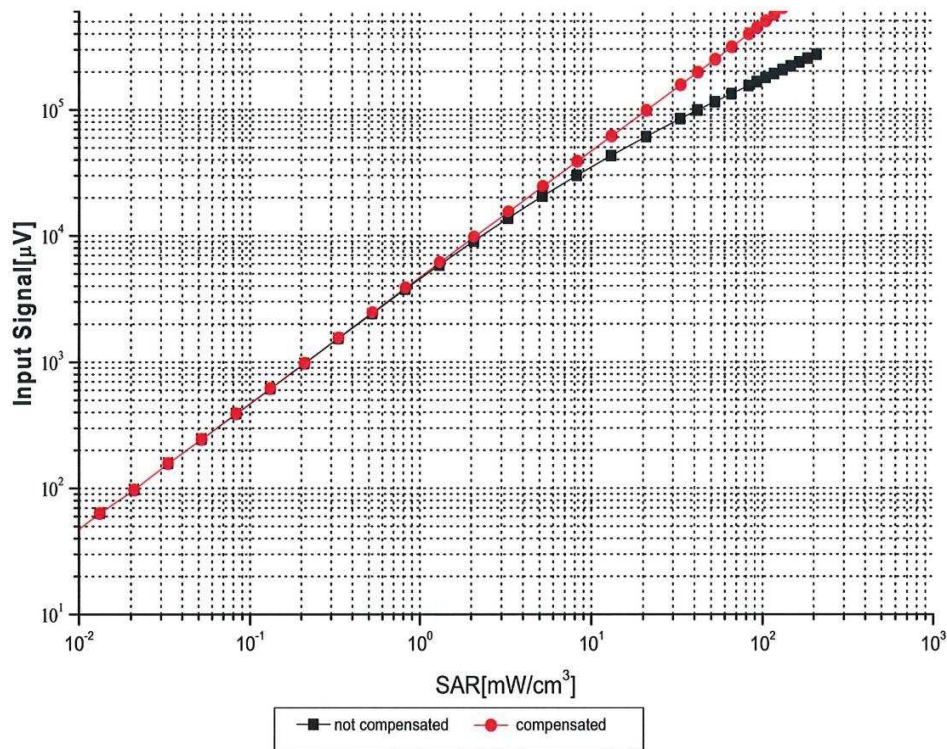


Uncertainty of Axial Isotropy Assessment: $\pm 1.2\%$ ($k=2$)



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Dynamic Range f(SAR_{head}) (TEM cell, f = 900 MHz)



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

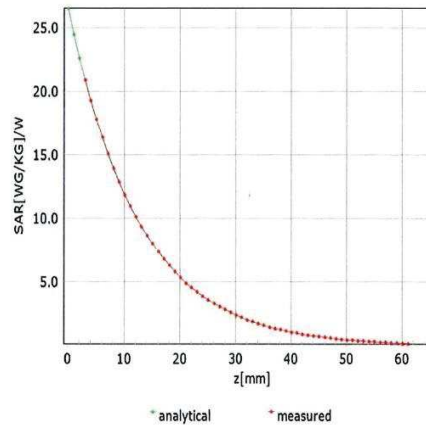
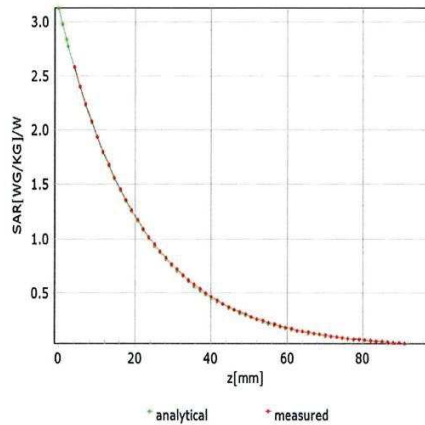


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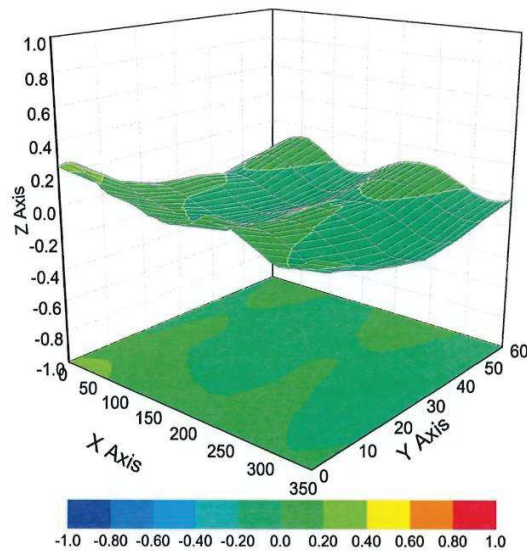
Conversion Factor Assessment

f=750 MHz,WGLS R9(H_convF)

f=1750 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:7322

Other Probe Parameters

| | |
|---|------------|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 41.2 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disable |
| Probe Overall Length | 337mm |
| Probe Body Diameter | 10mm |
| Tip Length | 9mm |
| 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 |



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CNAS L0570

Client : **Intertek**

Certificate No: 24J02Z000078

CALIBRATION CERTIFICATE

Object: DAE4 - SN: 1473

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

Calibration date: March 18, 2024

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 | 12-Jun-23 (CTTL, No.J23X05436) | Jun-24 |

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

Issued: March 20, 2024

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 | 404.013 ± 0.15% (k=2) | 404.606 ± 0.15% (k=2) | 404.459 ± 0.15% (k=2) |
| Low Range | 3.96391 ± 0.7% (k=2) | 3.99545 ± 0.7% (k=2) | 3.98870 ± 0.7% (k=2) |

Connector Angle

| | |
|---|------------|
| Connector Angle to be used in DASY system | 346° ± 1 ° |
|---|------------|



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CALIBRATION
CNAS L0570



Client **Intertek**

Certificate No: **24J02Z000850**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 966**

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

Calibration date: **November 6, 2024**

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 | 106276 | 17-May-24 (CTTL, No. J24X04107) | May-25 |
| Power sensor NRP6A | 101369 | 17-May-24 (CTTL, No. J24X04107) | May-25 |
| Reference Probe EX3DV4 | SN 7517 | 21-Feb-24(CTTL-SPEAG, No. 24J02Z80008) | Feb-25 |
| DAE4 | SN 1588 | 13-Sep-24(CTTL-SPEAG, No. 24J02Z000713) | Sep-25 |
| Secondary Standards | ID # | Cal Date (Calibrated by, Certificate No.) | Scheduled Calibration |
| Signal Generator E4438C | MY49071430 | 25-Dec-23 (CTTL, No. J23X13426) | Dec-24 |
| NetworkAnalyzer E5071C | MY46110673 | 25-Dec-23 (CTTL, No. J23X13425) | Dec-24 |
| OCP DAK-3.5(weighted) | 1040 | 22-Jan-24(SPEAG, No.OCP-DAK3.5-1040_Jan24) | Jan-25 |

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

Issued: November 15, 2024

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Glossary:

| | |
|-------|--|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORM _{x,y,z} |
| N/A | not applicable or not measured |

Calibration is Performed According to the Following Standards:

- a) IEC/IEEE 62209-1528, "Measurement Procedure for The Assessment of Specific Absorption Rate of Human Exposure to Radio Frequency Fields from Hand-held and Body-mounted Wireless Communication Devices- Part 1528: Human Models, Instrumentation and Procedures (Frequency range of 4 MHz to 10 GHz)", October 2020
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- c) 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.

| | | |
|-------------------------------------|--------------------------|-------------|
| DASY Version | DASY52 | 52.10.4 |
| 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 | 40.1 \pm 6 % | 1.81 mho/m \pm 6 % |
| Head TSL temperature change during test | <1.0 °C | ---- | ---- |

SAR result with Head TSL

| | | |
|---|--------------------|--|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR measured | 250 mW input power | 13.1 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 52.5 W/kg \pm 18.8 % (k=2) |
| SAR averaged over 10 cm³ (10 g) of Head TSL | Condition | |
| SAR measured | 250 mW input power | 6.07 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 24.3 W/kg \pm 18.7 % (k=2) |



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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

| | |
|--------------------------------------|---------------|
| Impedance, transformed to feed point | 51.5Ω+ 4.27jΩ |
| Return Loss | - 27.0dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.062 ns |
|----------------------------------|----------|

After long term use with 100W radiated power, only a slight warming of the dipole near the feed-point 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 feed-point may be damaged.

Additional EUT Data

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



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DASY5 Validation Report for Head TSL

Date: 2024-11-06

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 966

Communication System: UID 0, CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.809$ S/m; $\epsilon_r = 40.08$; $\rho = 1000$ kg/m³

Phantom section: Right Section

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

DASY5 Configuration:

- Probe: EX3DV4 - SN7517; ConvF(7.37, 7.37, 7.37) @ 2450 MHz; Calibrated: 2024-02-21
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1588; Calibrated: 2024-09-13
- Phantom: MFP_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx; Serial: 1062
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

dy=5mm, dz=5mm

Reference Value = 105.0 V/m; Power Drift = 0.00 dB

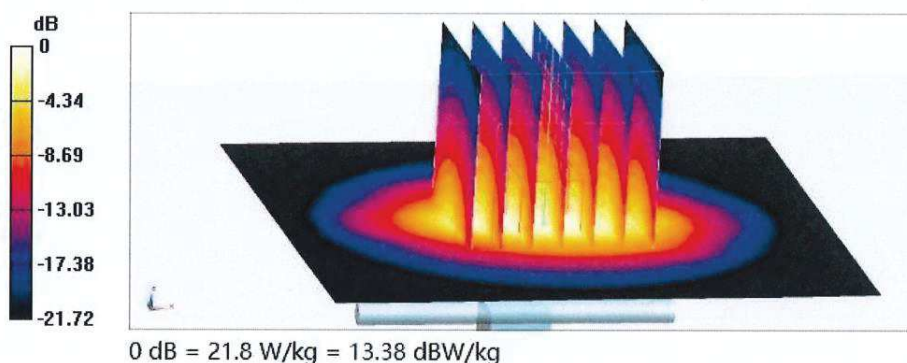
Peak SAR (extrapolated) = 26.7 W/kg

SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.07 W/kg

Smallest distance from peaks to all points 3 dB below = 8.2 mm

Ratio of SAR at M2 to SAR at M1 = 49.5%

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





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Impedance Measurement Plot for Head TSL

