

# FCC SAR Test Report

Client Name : Shanghai Helen Telecomm Co., Ltd.  
Address : Room 1206, No 75, Hailun Road, Hongkou District, Shanghai, China  
Product Name : Helen Two-Way Radio  
Date : Feb. 23, 2023

**Shenzhen Anbotek Compliance Laboratory Limited**




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# TEST REPORT

Applicant : Shanghai Helen Telecomm Co., Ltd.  
Manufacturer : Shanghai Helen Telecomm Co., Ltd.  
Product Name : Helen Two-Way Radio  
Model No. : Helen 228, Helen V8S, Helen 418, Helen 531, Helen 539, Helen 760,  
Helen 780  
Trade Mark : N/A  
Rating(s) : DC 7.4V From Battery

**Test Standard(s) : IEC/IEEE 62209-1528:2020;  
ANSI/IEEE C95.1:2005; FCC 47 CFR Part 2 (2.1093);**

The device described above is tested by Shenzhen Anbotek Compliance Laboratory Limited to determine the maximum emission levels emanating from the device and the severe levels of the device can endure and its performance criterion. The measurement results are contained in this test report and Shenzhen Anbotek Compliance Laboratory Limited is assumed full of responsibility for the accuracy and completeness of these measurements. Also, this report shows that the EUT (Equipment Under Test) is technically compliant with the IEC/IEEE 62209-1528:2020, FCC 47 CFR Part 2 (2.1093), ANSI/IEEE C95.1:2005 requirements.

This report applies to above tested sample only and shall not be reproduced in part without written approval of Shenzhen Anbotek Compliance Laboratory Limited.

Date of Test Mar. 14, 2022~ Feb. 23, 2023

Prepared By King Kong Jin  
(Engineer / Kingkong Jin)

Reviewer Bibo Zhang  
(Supervisor / Bibo Zhang)

Approved & Authorized Signer Tom Chen  
(Manager / Tom Chen)

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### Version

Version No.	Date	Description
01	Feb. 23, 2023	Original

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# 1. Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing are as follows.

### <Highest SAR Summary>

Mode	Channel Separation	Position	Maximum Report SAR Results (W/Kg)	Limit(W/Kg)
			50% duty cycle	
UHF	12.5KHz	Face-held	<b>0.490</b>	<b>1.6</b>
UHF	12.5KHz	Body-Worn	<b>0.831</b>	

This device is in compliance with Specific Absorption Rate (SAR) for general Occupational exposure / Controlled environment limits 1.6 W/kg) specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-2005, and had been tested in accordance with the measurement methods and procedures specified in IEC/IEEE 62209-1528:2020

## 2. General Information

### 2.1 Client Information

<b>Applicant:</b>	Shanghai Helen Telecomm Co., Ltd.
<b>Address of Applicant:</b>	Room 1206, No 75, Hailun Road, Hongkou District, Shanghai, China
<b>Manufacture:</b>	Shanghai Helen Telecomm Co., Ltd.
<b>Address of Manufacture:</b>	Room 1206, No 75, Hailun Road, Hongkou District, Shanghai, China

### 2.2 Testing Laboratory Information

<b>Test Site:</b>	Shenzhen Anbotek Compliance Laboratory Limited
<b>Address:</b>	1/F, Building D, Sogood Science and Technology Park, Sanwei community, Hangcheng Street, Bao'an District, Shenzhen, Guangdong, China.518102

### 2.3 Description of Equipment Under Test (EUT)

<b>Equipment</b>	Two-Way Radio
<b>Brand Name</b>	N/A
<b>Model Name</b>	Helen 228
<b>Listed Models</b>	Helen V8S, Helen 418, Helen 531, Helen 539, Helen 760, Helen 780
<b>Operation frequency range</b>	464.5 MHz to 469.9875MHz
<b>Channel Separation</b>	12.5kHz
<b>Type of Modulation</b>	Analog: FM Digital: 4FSK
<b>RF Rated Output power</b>	<=5W
<b>Power supply</b>	DC 7.4V From Battery
<b>Exposure category:</b>	Occupational exposure / Controlled environment
<b>Category of device</b>	Portable device
<b>Remark:</b>	1. The above DUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

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## 2. 4 Device Category and SAR Limits

This device belongs to portable device category because its radiating structure is allowed to be used within 20 centimeters of the body of the user. Limit for General Population/Uncontrolled exposure should be applied for this device, it is 8.0 W/kg as averaged over any 1 gram of tissue.

## 2. 5 Device Category and SAR Limits

This device belongs to portable device category because its radiating structure is allowed to be used within 20 centimeters of the body of the user. Limit for General Population/Uncontrolled exposure should be applied for this device, it is 8.0 W/kg as averaged over any 1 gram of tissue.

## 2. 6 Applied Standard

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

- FCC 47 CFR Part 2 (2.1093:2013)
- ANSI/IEEE C95.1:2005
- IEC/IEEE 62209-1528:2020
- KDB 643646 D01 v01r03: SAR Test reduction considerations for occupational PTT radio

## 2. 7 Environment of Test Site

Items	Required	Actual
Temperature (°C)	18-25	22~23
Humidity (%RH)	30-70	55~65

## 2. 8 Test Configuration

The device was controlled by using a base station emulator. Communication between the device and the emulator was established by air link. The distance between the EUT and the antenna of the emulator is larger than 50 cm and the output power radiated from the emulator antenna is at least 30 dB smaller than the output power of EUT. The EUT was set from the emulator to radiate maximum output power during all tests. For WLAN SAR testing, WLAN engineering testing software installed on the EUT can provide continuous transmitting RF signal.

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### 3. Specific Absorption Rate (SAR)

#### 3.1 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 modeling. 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.

#### 3.2 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:

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

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

SAR measurement can be either related to the temperature elevation in tissue by

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

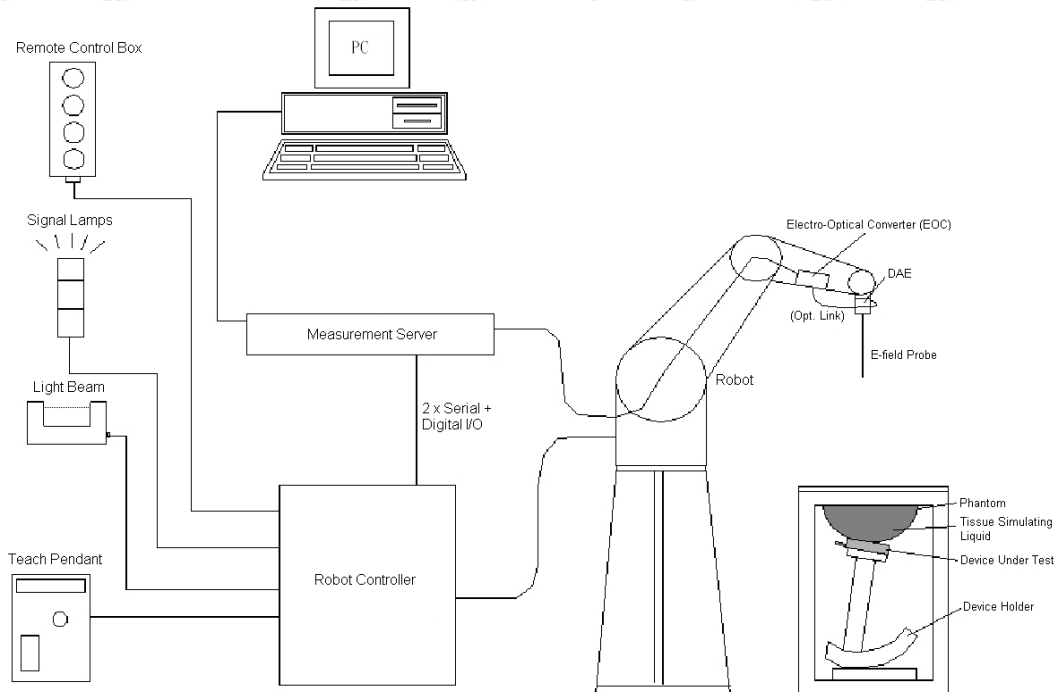
Where: C is the specific heat capacity, δT is the temperature rise and δt is the exposure duration, or related to the electrical field in the tissue by

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

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

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

## 4. SAR Measurement System



### DASy System Configurations

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

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

components are described in details in the following sub-sections.

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#### 4. 1 E-Field Probe

The SAR measurement is conducted with the dosimetric probe (manufactured by SPEAG).The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency. This probe has a built in optical surface detection system to prevent from collision with phantom.

##### ➤ E-Field Probe Specification

###### <EX3DV4 Probe>

<b>Construction</b>	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	 <p><b>Photo of EX3DV4</b></p>
<b>Frequency</b>	10 MHz to 6 GHz; Linearity: $\pm 0.2$ dB	
<b>Directivity</b>	$\pm 0.3$ dB in HSL (rotation around probe axis) $\pm 0.5$ dB in tissue material (rotation normal to probe axis)	
<b>Dynamic Range</b>	10 $\mu$ W/g to 100 mW/g; Linearity: $\pm 0.2$ dB (noise: typically $< 1$ $\mu$ W/g)	
<b>Dimensions</b>	Overall length: 330 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm	

##### ➤ E-Field Probe Calibration

Each probe needs to be calibrated according to a dosimetric assessment procedure with accuracy better than  $\pm 10\%$ . The spherical isotropy shall be evaluated and within  $\pm 0.25$ dB. The sensitivity parameters (NormX, NormY, and NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe are tested. The calibration data can be referred to appendix C of this report.

#### 4. 2 Data Acquisition Electronics (DAE)

The data acquisition electronics (DAE) consists 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 and 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 input impedance of the DAE is 200M $\Omega$ ; the inputs are symmetrical and floating. Common mode rejection is above 80dB.

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**Photo of DAE**

### 4. 3 Robot

The SPEAG DASY system uses the high precision robots (DASY5: TX60XL) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version (DASY5: CS8c) from Stäubli is used. The Stäubli robot series have many features that are important for our application:

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

**Photo of DASY5**

### 4. 4 Measurement Server

The measurement server is based on a PC/104 CPU board with CPU (DASY5: 400 MHz, Intel Celeron), chip disk (DASY5: 128 MB), RAM (DASY5: 128 MB). 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.

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The measurement server performs all the real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operations.



**Photo of Server for DASY5**

**4. 5 Phantom**

**<SAM Twin Phantom>**

<b>Shell Thickness</b>	2 ± 0.2 mm; Center ear point: 6 ± 0.2 mm
<b>Filling Volume</b>	Approx. 25 liters
<b>Dimensions</b>	Length: 1000 mm; Width: 500 mm; Height: adjustable feet
<b>Measurement Areas</b>	Left Hand, Right Hand, Flat Phantom



The bottom plate contains three pair of bolts for locking the device holder. The device holder positions are adjusted to the standard measurement positions in the three sections. A white cover is provided to tap the phantom during off-periods to prevent water evaporation and changes in the liquid parameters. On the phantom top, three reference markers are provided to identify the phantom position with respect to the robot.

**<ELI4 Phantom>**

<b>Shell Thickness</b>	2 ± 0.2 mm (sagging: <1%)
<b>Filling Volume</b>	Approx. 30 liters
<b>Dimensions</b>	Major ellipse axis: 600 mm Minor axis: 400 mm



The ELI4 phantom is intended for compliance testing of handheld and body-mounted wireless devices in the

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frequency range of 30 MHz to 6 GHz. ELI4 is fully compatible with standard and all known tissue simulating liquids.

#### 4. 6 Device Holder

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 5 mm 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 different positions given in the standard. It has two scales for the device rotation (with respect to the body axis) and the device inclination (with respect to the line between the ear reference points). The rotation center for both scales is 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.



**Device Holder**

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#### 4. 7 Data Storage and Evaluation

➤ Data Storage

The DASY software stores the assessed data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all the necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files. The post-processing 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 erroneous parameter settings. For example, if a measurement has been performed with an incorrect crest factor parameter in the device setup, the parameter can be corrected afterwards and the data can be reevaluated.

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

➤ Data Evaluation

The DASY post-processing software (SEMCAD) 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:

<b>Probe parameters:</b>	- Sensitivity	Norm <sub>i</sub> , a <sub>i0</sub> , a <sub>i1</sub> , a <sub>i2</sub>
	- Conversion factor	ConvF <sub>i</sub>
	- Diode compression point	dcp <sub>i</sub>
<b>Device parameters:</b>	- Frequency	f
	- Crest factor	cf
<b>Media parameters:</b>	- Conductivity	σ
	- Density	ρ

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 DASY components. In the direct measuring mode of the multi-meter 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:

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

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:

$$\text{E-field Probes: } E_i = \sqrt{\frac{V_i}{\text{Norm}_i \cdot \text{ConvF}}}$$

$$\text{H-field Probes: } H_i = \sqrt{V_i \cdot \frac{a_{i0} + a_{i1}f + a_{i2}f^2}{f}}$$

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

$\text{Norm}_i$  = sensor sensitivity of channel  $i$ , ( $i = x, y, z$ ),  $\mu\text{V}/(\text{V/m})^2$  for E-field Probes

$\text{ConvF}$  = 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):

$$E_{\text{tot}} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

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

$$\text{SAR} = E_{\text{tot}}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

with SAR = local specific absorption rate in mW/g

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

$\sigma$  = conductivity in [mho/m] or [Siemens/m]

$\rho$  = equivalent tissue density in  $\text{g/cm}^3$

Note that the density is set to 1, to account for actual head tissue density rather than the density of the tissue simulating liquid.



## 5. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	450MHz System Validation Kit	D450V3	1079	Aug 28,2022	Aug 27,2025
SPEAG	Data Acquisition Electronics	DAE4	387	Sept.06,2022	Sept.05,2023
SPEAG	Dosimetric E-Field Probe	ES3DV3	3292	Jan. 25,2023	Jan. 24,2024
Agilent	ENA Series Network Analyzer	E5071C	MY46317418	Oct.22, 2022	Oct.21, 2023
SPEAG	DAK	DAK-3.5	1226	NCR	NCR
SPEAG	SAM Twin Phantom	QD000P40CD	1802	NCR	NCR
AR	Amplifier	ZHL-42W	QA1118004	NCR	NCR
Agilent	Power Meter	N1914A	MY50001102	Oct.22, 2022	Oct.21, 2023
Agilent	Power Sensor	N8481H	MY51240001	Oct.22, 2022	Oct.21, 2023
R&S	Spectrum Analyzer	N9020A	MY51170037	Oct.22, 2022	Oct.21, 2023
Agilent	Signal Generation	N5182A	MY48180656	Oct.22, 2022	Oct.21, 2023
Worken	Directional Coupler	0110A056010-1 0	COM5BNW1A2	Oct.22, 2022	Oct.21, 2023

**Note:**

1. The calibration certificate of DASY can be referred to appendix C of this report.
2. The dipole calibration interval can be extended to 3 years with justification. The dipoles are also not physically damaged, or repaired during the interval.
3. The Insertion Loss calibration of Dual Directional Coupler and Attenuator were characterized via the network analyzer and compensated during system check.
4. The dielectric probe kit was calibrated via the network analyzer, with the specified procedure (calibrated in pure water) and calibration kit (standard) short circuit, before the dielectric measurement. The specific procedure and calibration kit are provided by Agilent.
5. In system check we need to monitor the level on the power meter, and adjust the power amplifier level to have precise power level to the dipole; the measured SAR will be normalized to 1W input power according to the ratio of 1W to the input power to the dipole. For system check, the calibration of the power amplifier is deemed not critically required for correct measurement; the power meter is critical and we do have calibration for it

## 6. Tissue Simulating Liquids

For the measurement of the field distribution inside the SAM phantom with DASY, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. For head SAR testing, the liquid height from the ear reference point (ERP) of the phantom to the liquid top surface is larger than 15 cm. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm, which is shown as followed:

The following table gives the recipes for tissue simulating liquid.

Composition of the Head Tissue Equivalent Matter

Mixture %	Frequency 450MHz
Water	38.56
Sugar	56.32
Salt	3.95
Preventol	0.10
Cellulose	1.07
Dielectric Parameters Target Value	f=450MHz $\epsilon_r=43.5$ $\sigma=0.87$

Composition of the Body Tissue Equivalent Matter

Mixture %	Frequency 450MHz
Water	56.16
Sugar	46.78
Salt	1.49
Preventol	0.10
Cellulose	0.47
Dielectric Parameters Target Value	f=450MHz $\epsilon_r=56.7$ $\sigma=0.94$

The following table shows the measuring results for simulating liquid.

Tissue Type	Measured Frequency (MHz)	Target Tissue		Measured Tissue			Liquid Temp.( °C)	Test Data	
		$\epsilon_r$	$\sigma$	$\epsilon_r$	Dev.	$\sigma$			Dev.
450H	450	43.50	0.87	43.68	0.41%	0.89	2.30%	22.2	Feb. 16, 2023
450B	450	56.70	0.94	56.35	-0.62%	0.93	-1.06%	22.2	Feb. 16, 2023

## 7. System Verification Procedures

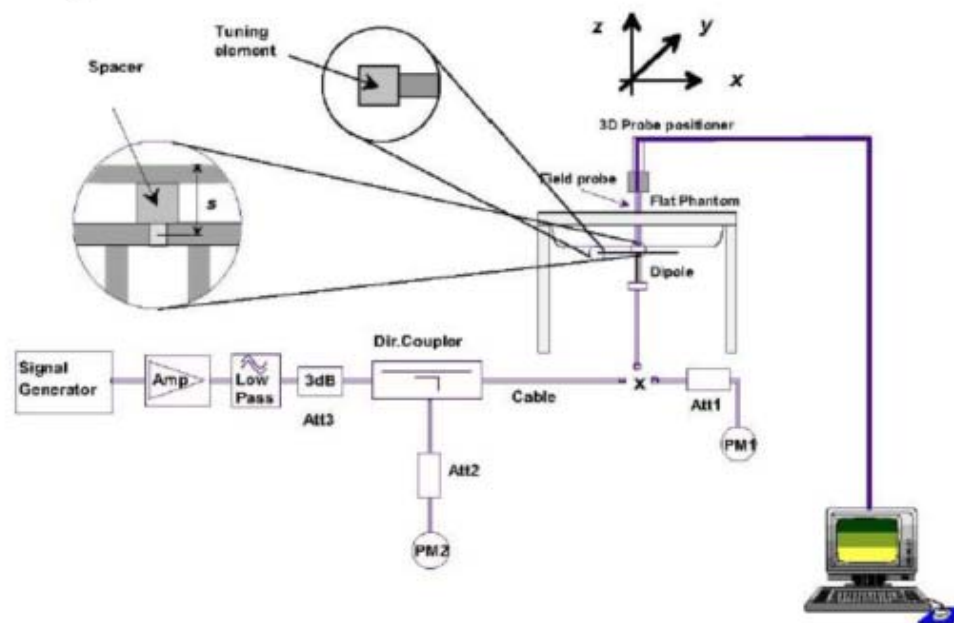
Each DASY system is equipped with one or more system validation kits. These units, together with the predefined measurement procedures within the DASY software, enable the user to conduct the system performance check and system validation. System validation kit includes a dipole, tripod holder to fix it underneath the flat phantom and a corresponding distance holder.

### ➤ Purpose of System Performance check

The system performance check verifies that the system operates within its specifications. System and operator errors can be detected and corrected. It is recommended that the system performance check be performed prior to any usage of the system in order to guarantee reproducible results. The system performance check uses normal SAR measurements in a simplified setup with a well characterized source. This setup was selected to give a high sensitivity to all parameters that might fail or vary over time. The system check does not intend to replace the calibration of the components, but indicates situations where the system uncertainty is exceeded due to drift or failure.

### ➤ System Setup

In the simplified setup for system evaluation, the EUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave that comes from a signal generator. The calibrated dipole must be placed beneath the flat phantom section of the SAM twin phantom with the correct distance holder. The distance holder should touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The equipment setup is shown below:



**System Setup for System Evaluation**

➤ **Validation Results**

Comparing to the original SAR value provided by SPEAG, the verification data should be within its specification of 10 %. The table below shows the target SAR and measured SAR after normalized to 1W input power. It indicates that the system performance check can meet the variation criterion and the plots can be referred to Appendix A of this report.

Date	Frequency (MHz)	Liquid Type	Power fed onto reference dipole (mW)	Targeted SAR (W/kg)	Measured SAR (W/kg)	Normalized SAR (W/kg)	Deviation
Feb. 16, 2023	450	Head	250	4.58	1.16	4.64	1.31%
Feb. 16, 2023	450	Body	250	4.60	1.16	4.64	0.87%

**Target and Measurement SAR after Normalized**

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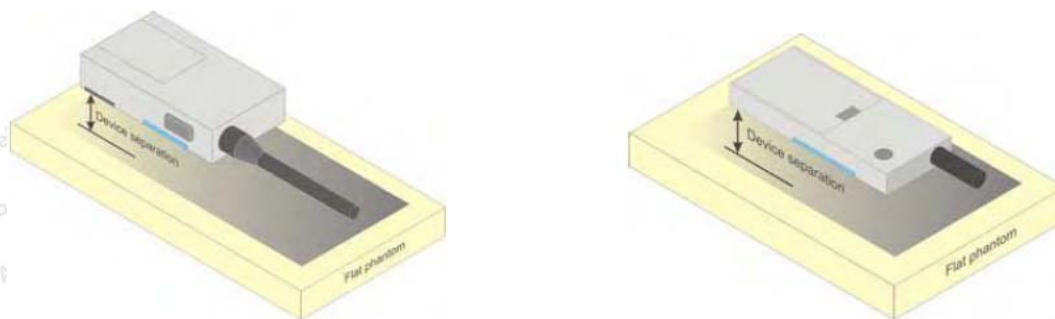
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## 8. EUT Testing Position

### 8.1 Front-of-face

A typical example of a front-of-face device is a two-way radio that is held at a distance from the face of the user when transmitting. In these cases the device under test shall be positioned at the distance to the phantom surface that corresponds to the intended use as specified by the manufacturer in the user instructions (Figure 8a). If the intended use is not specified, a separation distance of 25 mm between the phantom surface and the device shall be used.



Test positions for front-of-face devices

### 8.2 Body Worn Position

Body-worn operating configurations are tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in a normal use configuration. Per KDB 648474 D04, body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories. The body-worn accessory procedures in FCC KDB 447498 D01 should be used to test for body-worn accessory SAR compliance, without a headset connected to it. This enables the test results for such configuration to be compatible with that required for hotspot mode when the body-worn accessory test separation distance is greater than or equal to that required for hotspot mode, when applicable. When the reported SAR for body-worn accessory, measured without a headset connected to the handset is  $< 1.2$  W/kg, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for that body-worn accessory with a handset attached to the handset.

Accessories for body-worn operation configurations are divided into two categories: those that do not contain metallic components and those that do contain metallic components and those that do contain metallic components. When multiple accessories that do not contain metallic components are supplied with the device, the device is tested with only the accessory that dictates the closest spacing to the body. Then multiple accessories that contain metallic components are test with the device with each accessory. If multiple accessories share an identical metallic component (i.e. the same metallic belt-chip used with

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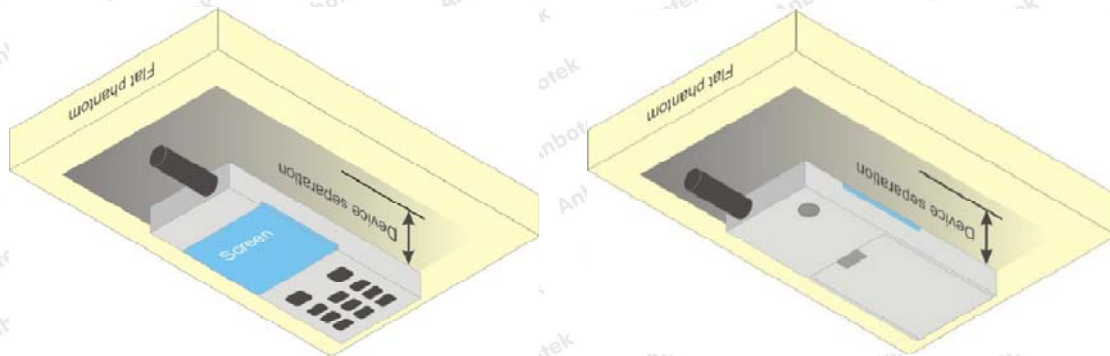


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different holsters with no other metallic components) only the accessory that dictates the closest spacing to the body is tested.



**Body Worn Position**

## 9. Measurement Procedures

The measurement procedures are as follows:

- (a) Use base station simulator (if applicable) or engineering software to transmit RF power continuously (continuous Tx) in the middle channel.
- (b) Keep EUT to radiate maximum output power or 100% duty factor (if applicable)
- (c) Measure output power through RF cable and power meter.
- (d) Place the EUT in the positions as setup photos demonstrates.
- (e) Set scan area, grid size and other setting on the DASY software.
- (f) Measure SAR transmitting at the middle channel for all applicable exposure positions.
- (g) Identify the exposure position and device configuration resulting the highest SAR
- (h) Measure SAR at the lowest and highest channels at the worst exposure position and device configuration.

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

- (a) Power reference measurement
- (b) Area scan
- (c) Zoom scan
- (d) Power drift measurement

### 9.1 Spatial Peak SAR Evaluation

The procedure for spatial peak SAR evaluation has been implemented according to the test standard. It can be conducted for 1g and 10g, 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 1g and 10g 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 1g and 10g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

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

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### 9.2 Power Reference Measurement

The Power Reference Measurement and Power Drift Measurements are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

### 9.3 Area Scan Procedures

The area scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASYS software can find the maximum found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE standard 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan), if only one zoom scan follows the area scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of zoom scans has to be increased accordingly.

Area scan parameters extracted from FCC KDB 865664 D01 SAR measurement 100 MHz to 6 GHz.

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	30° ± 1°	20° ± 1°
Maximum area scan spatial resolution: $\Delta x_{Area}$ , $\Delta y_{Area}$	< 2 GHz: < 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: < 12 mm 4 – 6 GHz: ≤ 10 mm
	When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	



**9.4 Zoom Scan Procedures**

Zoom scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 gram and 10gram of simulated tissue. The zoom scan measures points (refer to table below) within a cube whose base faces are centered on the maxima found in a preceding area scan job within the same procedure. When the measurement is done, the zoom scan evaluates the averaged SAR for 1 gram and 10 gram and displays these values next to the job's label.

Zoom scan parameters extracted from FCC KDB 865664 D01 SAR measurement 100 MHz to 6 GHz.

			$\leq 3$ GHz	$> 3$ GHz
Maximum zoom scan spatial resolution: $\Delta x_{Zoom}, \Delta y_{Zoom}$			$\leq 2$ GHz: $\leq 8$ mm 2 – 3 GHz: $\leq 5$ mm *	3 – 4 GHz: $\leq 5$ mm * 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 4 – 5 GHz: $\leq 3$ mm 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 4 – 5 GHz: $\leq 2.5$ mm 5 – 6 GHz: $\leq 2$ mm
		$\Delta z_{Zoom}(n>1)$ : between subsequent points	$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z	$\geq 30$ mm	3 – 4 GHz: $\geq 28$ mm 4 – 5 GHz: $\geq 25$ mm 5 – 6 GHz: $\geq 22$ mm	
<p>Note: <math>\delta</math> is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.</p> <p>* When zoom scan is required and the <i>reported</i> SAR from the <i>area scan based 1-g SAR estimation</i> procedures of KDB 447498 is <math>\leq 1.4</math> W/kg, <math>\leq 8</math> mm, <math>\leq 7</math> mm and <math>\leq 5</math> mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.</p>				

## 9.5 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 1g aggregate SAR, the EUT 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.

## 9.6 Power Drift Monitoring

All SAR testing is under the EUT 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 EUT 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 drift more than 5%, the SAR will be retested.

## 10. Conducted Power

Modulation Type	Channel Separation	Test Channel	Test Frequency (MHz)	Transmitter Power	Tune up Power
				High power level	High power level
				(dBm)	(dBm)
Analog / FM	12.5KHz	Ch1	464.5	37.314	37.5
		Ch2	467.8125	37.321	37.5
		Ch3	469.9875	37.432	37.5
Digital	12.5KHz	Ch1	464.5	37.124	37.5
		Ch2	467.8125	37.167	37.5
		Ch3	467.925	37.241	37.5

**Note:**

1. The high power level adjust by software, without any modification for hardware.

## 11.SAR Test Results Summary

General Note:

- Per KDB 447498 D01v05r01, the reported SAR is the measured SAR value adjusted for maximum tune-up tolerance.

*Scaling Factor = tune-up limit power (mW) / EUT RF power (mW), where tune-up limit is the maximum rated power among all production units.*

$$Max\_Calc = SAR\_Adju * DC * (P\_max / P\_cond)$$

*P\_max = highest power including turn up tolerance (W)*

*P\_cond\_high = highest power in conduct measured (W)*

*DC = Transmission mode Duty Cycle in % where applicable 50% duty cycle is applied for PTT operation*

*SAR\_meas. = Measured SAR (W/kg)*

< Analog >

Plot No.	Test Position	Test Frequency (MHz)	Mode	Gap (cm)	Average Power (dBm)	Tune-Up Limit (dBm)	Scaling Factor	Power Drift (dB)	Measured SAR <sub>1g</sub> (W/kg)	Reported SAR <sub>1g</sub> (W/kg)	50% Duty SAR <sub>1g</sub> (W/kg)
#1	Front of face	464.5	Analog	2.5	37.314	37.5	1.005	0.10	0.812	0.816	0.408
	Front of face	467.8125	Analog	2.5	37.421	37.5	1.002	0.10	0.887	0.889	<b>0.444</b>
	Front of face	469.9875	Analog	2.5	37.332	37.5	1.005	0.05	0.843	0.847	0.423
#2	body-worn	464.5	Analog	0	37.314	37.5	1.005	0.06	1.359	0.718	0.359
	body-worn	467.8125	Analog	0	37.421	37.5	1.002	-0.09	1.561	1.564	<b>0.782</b>
	body-worn	469.9875	Analog	0	37.332	37.5	1.005	-0.06	1.551	1.558	0.779
#3	Front of face	464.5	Digital	2.5	37.124	37.5	1.010	0.06	0.921	0.930	0.465
	Front of face	467.8125	Digital	2.5	37.267	37.5	1.006	0.05	0.974	0.980	<b>0.490</b>
	Front of face	467.925	Digital	2.5	37.241	37.5	1.007	0.14	0.908	0.914	0.457
	body-worn	464.5	Digital	0	37.124	37.5	1.010	0.08	1.524	1.539	0.770
#4	body-worn	467.8125	Digital	0	37.267	37.5	1.006	-0.08	1.652	1.662	<b>0.831</b>
	body-worn	467.925	Digital	0	37.241	37.5	1.007	0.10	1.421	1.431	0.715

### SAR Test Considerations Note:

- Passive body-worn and audio accessories generally do not apply to the head SAR of PTT radios. Head SAR is measured with the front surface of the radio positioned at 2.5 cm parallel to a flat phantom. A phantom shell thickness of 2 mm is required. When the front of the radio has a contour or non-uniform surface with a variation of 1.0 cm or more, the average distance of such variations is used to establish the 2.5 cm test separation from the phantom.
- Testing antennas with the default battery:
  - Start by testing a PTT radio with a standard battery (default battery) that is supplied with the radio to measure the head SAR of each antenna on the highest output power channel, according to the test channels required by the number-of-test-channels formula in KDB Publication 447498 D01 and in the frequency range covered by each antenna within the operating

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frequency bands of the radio. When multiple standard batteries are supplied with a radio, the battery with the highest capacity is considered the default battery for making head SAR measurements.

3. Body SAR is measured with the radio placed in a body-worn accessory, positioned against a flat phantom, representative of the normal operating conditions expected by users and typically with a standard default audio accessory supplied with the radio. Since audio accessories, including any default audio accessories supplied with a radio, may be designed to operate with a subset of the combinations of antennas, batteries and body-worn accessories, when a default audio accessory does not fully support all the test configurations required in this section for body-worn accessories testing an alternative audio accessory must be selected to be the default audio accessory for body-worn accessories testing.9 If an alternative audio accessory cannot be identified, body-worn accessories should be tested without any audio accessory. In general, all sides of the radio that may be positioned facing the user when using a body-worn accessory must be considered for SAR compliance.



## 12.SAR Measurement Variability

SAR measurement variability must be assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media are required for SAR measurements in a frequency band, the variability measurement procedures should be applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium. The following procedures are applied to determine if repeated measurements are required.

- 1) Repeated measurement is not required when the original highest measured SAR is  $< 0.80$  W/kg; steps 2) through 4) do not apply.
- 2) When the original highest measured SAR is  $\geq 0.80$  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  $> 1.20$  or when the original or repeated measurement is  $\geq 1.45$  W/kg (~ 10% from the 1-g SAR limit).
- 4) Perform a third repeated measurement only if the original, first or second repeated measurement is  $\geq 1.5$  W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is  $> 1.20$ .

The same procedures should be adapted for measurements according to extremity and occupational exposure limits by applying a factor of 2.5 for extremity exposure and a factor of 5 for occupational exposure to the corresponding SAR thresholds.

Thus the following procedures are applied to determine if repeated measurements are required for occupational exposure.

- 5) Repeated measurement is not required when the original highest measured SAR is  $< 4.00$  W/kg; steps 6) through 8) do not apply.
- 6) When the original highest measured SAR is  $\geq 4.00$  W/kg, repeat that measurement once.
- 7) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is  $> 6.00$  or when the original or repeated measurement is  $\geq 7.25$  W/kg (~ 10% from the 1-g SAR limit).
- 8) Perform a third repeated measurement only if the original, first or second repeated measurement is  $\geq 7.5$  W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is  $> 1.20$ .


## 13.Measurement Uncertainty

NO	Source	Uncert. ai (%)	Prob. Dist.	Div. k	ci (1g)	ci (10g)	Stand.Un cert. ui (1g)	Stand.Un cert. ui (10g)	Veff
1	Repeat	0.4	N	1	1	1	0.4	0.4	9
<b>Instrument</b>									
2	Probe calibration	7	N	2	1	1	3.5	3.5	∞
3	Axial isotropy	4.7	R	$\sqrt{3}$	0.7	0.7	1.9	1.9	∞
4	Hemispherical isotropy	9.4	R	$\sqrt{3}$	0.7	0.7	3.9	3.9	∞
5	Boundary effect	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
6	Linearity	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
7	Detection limits	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
8	Readout electronics	0.3	N	1	1	1	0.3	0.3	∞
9	Response time	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
10	Integration time	2.6	R	$\sqrt{3}$	1	1	1.5	1.5	∞
11	Ambient noise	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
12	Ambient reflections	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
13	Probe positioner mech. restrictions	0.4	R	$\sqrt{3}$	1	1	0.2	0.2	∞
14	Probe positioning with respect to phantom shell	2.9	R	$\sqrt{3}$	1	1	1.7	1.7	∞
15	Max.SAR evaluation	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
<b>Test sample related</b>									

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16	Device positioning	3.8	N	1	1	1	3.8	3.8	99
17	Device holder	5.1	N	1	1	1	5.1	5.1	5
18	Drift of output power	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	$\infty$
<b>Phantom and set-up</b>									
19	Phantom uncertainty	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	$\infty$
20	Liquid conductivity (target)	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	$\infty$
21	Liquid conductivity (meas)	2.5	N	1	0.64	0.43	1.6	1.2	$\infty$
22	Liquid Permittivity (target)	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.5	$\infty$
23	Liquid Permittivity (meas)	2.5	N	1	0.6	0.49	1.5	1.2	$\infty$
<b>Combined standard</b>			RSS	$U_c = \sqrt{\sum_{i=1}^n c_i^2 U_i^2}$			11.4%	11.3%	236
<b>Expanded uncertainty(P=95%)</b>			$U = k U_c, k=2$				<b>22.8%</b>	<b>22.6%</b>	



## Appendix A. Test Setup Photos



**Face-held, the front of the EUT towards phantom (The distance was 25mm)**



**Body-worn, the front of the EUT towards ground (The distance was 0mm)**

## Appendix B. Plots of SAR System Check

### System Performance Check at 450 MHz Head TSL

DUT: Dipole450 MHz; Type: D450V2; Serial: 1072

Date/Time: Feb. 16, 2023

Communication System: DuiJiangJi; Frequency: 450 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated):  $f = 450$  MHz;  $\sigma = 0.89$  S/m;  $\epsilon_r = 43.68$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY5 Configuration:

Probe: ES3DV3 - SN3292; ConvF(7.12, 7.12, 7.12); Calibrated: 01/25/2023;

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: 09/06/2022

Phantom: ELI 4.0; Type: QDOVA001BA;

Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

**System Performance Check at 450MHz/Area Scan (61x201x1):** Interpolated grid: dx=1.50 mm, dy=1.50 mm

Maximum value of SAR (interpolated) = 1.47 mW/g

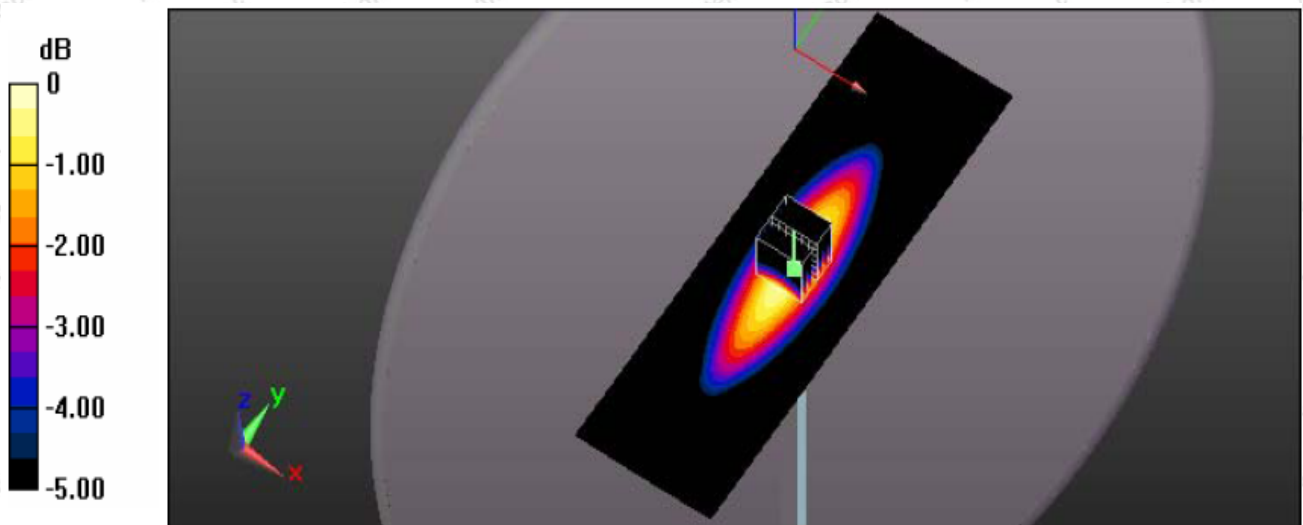
**System Performance Check at 450MHz/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 41.24 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 1.72 mW/g

**SAR(1 g) = 1.16 mW/g; SAR(10 g) = 0.781 mW/g**

Maximum value of SAR (measured) = 1.42 mW/g



System Performance Check 450MHz Head 250mW

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**System Performance Check at 450 MHz Body TSL**

DUT: Dipole450 MHz; Type: D450V2; Serial: 1072

Date/Time: Feb. 16, 2023

Medium parameters used (interpolated):  $f = 450$  MHz;  $\sigma = 0.93$  S/m;  $\epsilon_r = 56.35$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Communication System: DuiJiangJi; Frequency: 450 MHz; Duty Cycle: 1:1

Phantom section: Flat Section

**DASY5 Configuration:**

Probe: ES3DV3 - SN3292; ConvF(7.28, 7.28, 7.28); Calibrated: 01/25/2023;

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: 09/06/2022

Phantom: ELI 4.0; Type: QDOVA001BA;

Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

**System Performance Check at 450MHz/Area Scan (61x201x1):** Interpolated grid: dx=1.500 mm, dy=1.50 mm

Maximum value of SAR (interpolated) = 1.48 mW/g

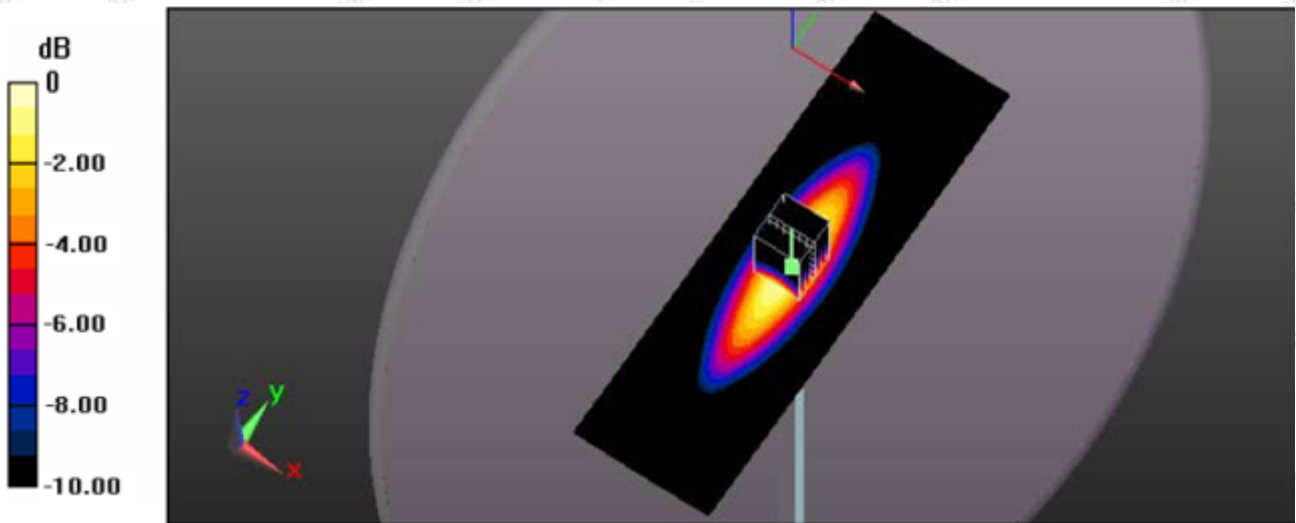
**System Performance Check at 450MHz/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 40.34 V/m; Power Drift = -0.11 dB

Peak SAR (extrapolated) = 1.78 mW/g

**SAR(1 g) = 1.16 mW/g; SAR(10 g) = 0.772 mW/g**

Maximum value of SAR (measured) = 1.49 mW/g



System Performance Check 450MHz Body 250mW

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## Appendix C. Plots of SAR Test Data

### Face Held for FM Modulation at 12.5 KHz Channel Separation, Front towards Phantom 467.8125 MHz

Communication System: Customer System; Frequency: 467.8125 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated):  $f = 467.8125$  MHz;  $\sigma = 0.89$  S/m;  $\epsilon_r = 43.68$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Head Section

DASY5 Configuration:

Probe: ES3DV3 - SN3292; ConvF(7.12, 7.12, 7.12); Calibrated: 01/25/2023;

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: 09/06/2022

Phantom: ELI 4.0; Type: QDOVA001BA;

Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

**Area Scan(51x181x1):** Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 1.285 W/kg

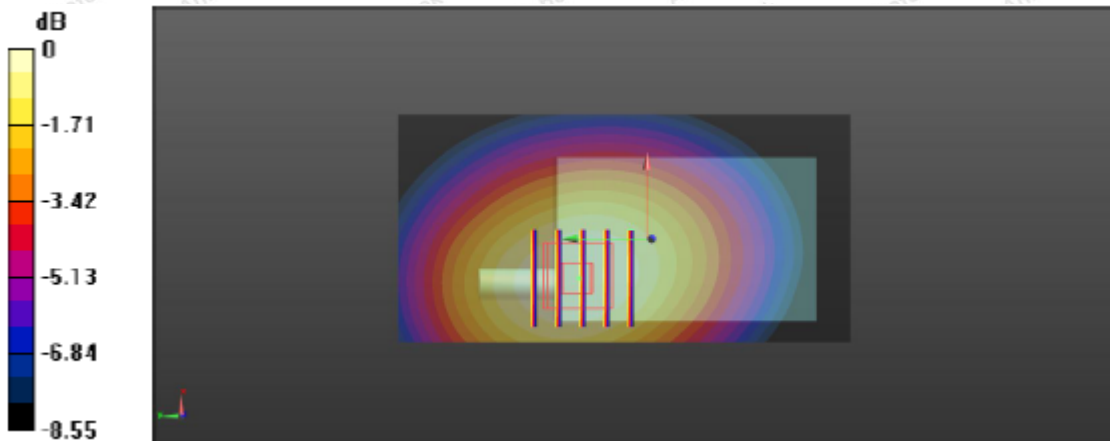
**Zoom Scan (5x5x6)/Cube 0:** Measurement grid: dx=7mm, dy=7mm, dz=5mm

Reference Value = 16.289 V/m; Power Drift = 0.10dB

Peak SAR (extrapolated) = 0.987 mW/g

**SAR(1 g) = 0.887 mW/g; SAR(10 g) = 0.686 mW/g**

Maximum value of SAR (measured) = 0.975 W/kg



**Body-Worn FM Modulation at 12.5 KHz Channel Separation, Front towards Ground 467.8125 MHz**

Communication System: PTT450; Frequency: 462.725 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated):  $f = 462.725$  MHz;  $\sigma = 0.93$  S/m;  $\epsilon_r = 56.35$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section : Flat Section

DASY5 Configuration:

Probe: ES3DV3 - SN3292; ConvF(7.28, 7.28, 7.28); Calibrated: 01/25/2023;

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: 09/06/2022

Phantom: ELI 4.0; Type: QDOVA001BA;

Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

**Area Scan(51x181x1):** Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 1.732 mW/g

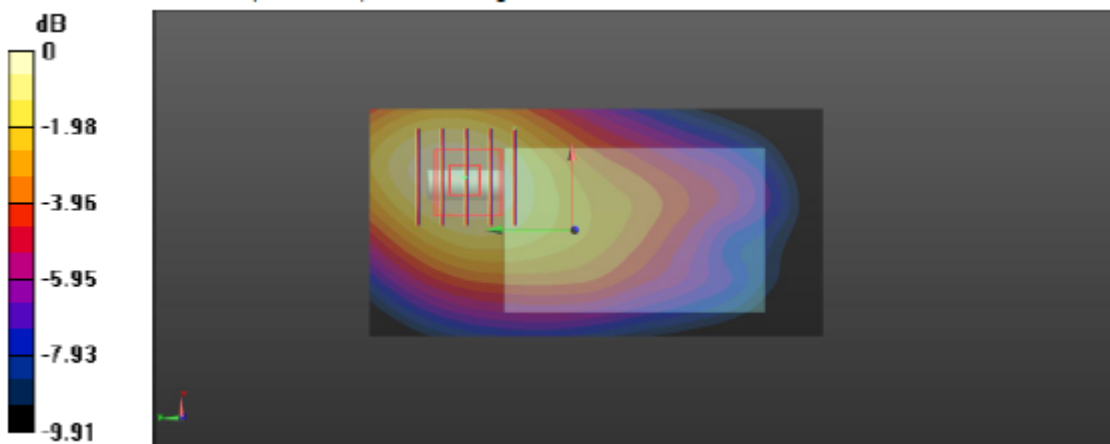
**Zoom Scan (5x5x6)/Cube 0:** Measurement grid: dx=7mm, dy=7mm, dz=5mm

Reference Value = 46.527 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 1.891 mW/g

**SAR(1 g) = 1.561 mW/g; SAR(10 g) = 0.785 mW/g**

Maximum value of SAR (measured) = 1.631 mW/g



**Face Held for 4FSK Modulation at 12.5 KHZ Channel Separation, Front towards Phantom 467.8125 MHz**

Communication System: Customer System; Frequency: 467.5625 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated):  $f = 467.5625$  MHz;  $\sigma = 0.89$  S/m;  $\epsilon_r = 43.68$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Head Section

DASY5 Configuration:

Probe: ES3DV3 - SN3292; ConvF(7.12, 7.12, 7.12); Calibrated: 01/25/2023;

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: 09/06/2022

Phantom: ELI 4.0; Type: QDOVA001BA;

Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

**Area Scan(51x181x1):** Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 1.552 W/kg

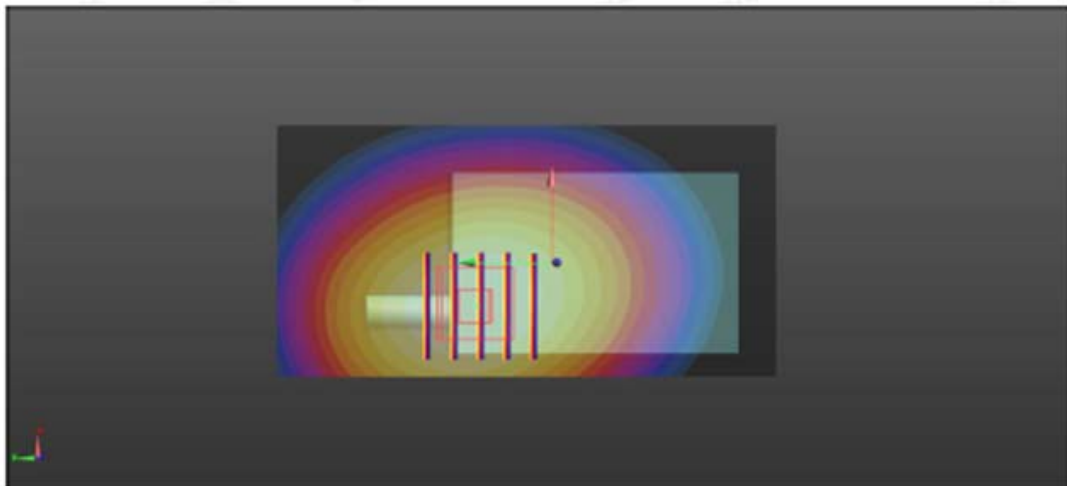
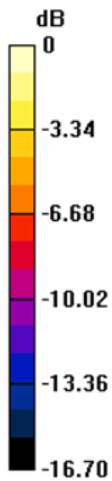
**Zoom Scan (5x5x6)/Cube 0:** Measurement grid: dx=7mm, dy=7mm, dz=5mm

Reference Value = 16.784 V/m; Power Drift = 0.05dB

Peak SAR (extrapolated) = 1.057 mW/g

**SAR(1 g) = 0.974 mW/g; SAR(10 g) = 0.686 mW/g**

Maximum value of SAR (measured) = 1.097 W/kg



## Body-Worn 4FSK Modulation at 12.5 KHz Channel Separation, Front towards Ground 467.8125 MHz

Communication System: PTT450; Frequency: 462.725 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated):  $f = 462.725$  MHz;  $\sigma = 0.93$  S/m;  $\epsilon_r = 56.35$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section : Flat Section

DASY5 Configuration:

Probe: ES3DV3 - SN3292; ConvF(7.28, 7.28, 7.28); Calibrated: 01/25/2023;

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: 09/06/2022

Phantom: ELI 4.0; Type: QDOVA001BA;

Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

**Area Scan(51x181x1):** Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 2.237 mW/g

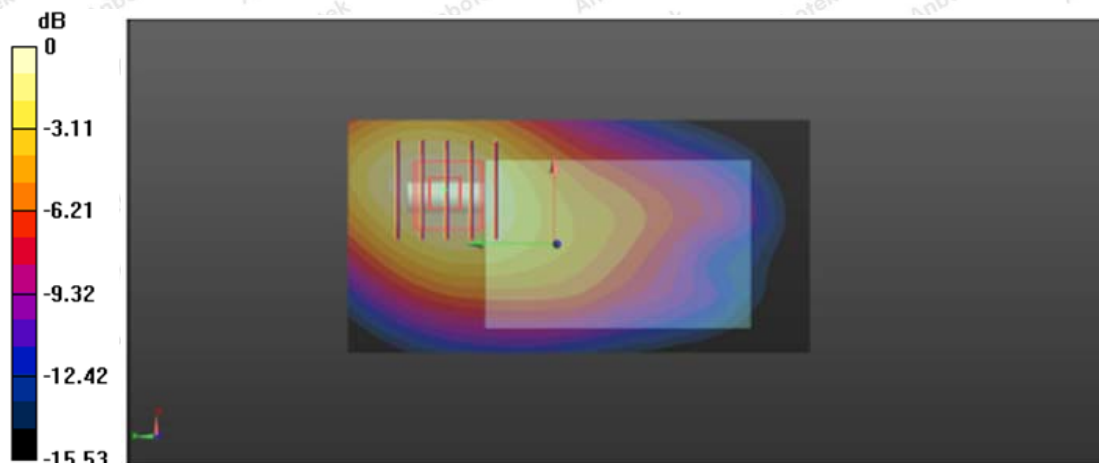
**Zoom Scan (5x5x6)/Cube 0:** Measurement grid: dx=7mm, dy=7mm, dz=5mm

Reference Value = 46.255 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 1.951 mW/g

**SAR(1 g) = 1.652 mW/g; SAR(10 g) = 0.985 mW/g**

Maximum value of SAR (measured) = 1.978 mW/g



# Appendix D. DASYS System Calibration Certificate

**Calibration Laboratory of Schmid & Partner Engineering AG**  
Zeughausstrasse 43, 8004 Zurich, Switzerland



**S** Schweizerischer Kalibrierdienst  
**C** Service suisse d'étalonnage  
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Accreditation No.: **SCS 0108**

Client **CIQ-SZ (Auden)**

Certificate No: **ES3-3292\_Jan18**

## CALIBRATION CERTIFICATE

Object: **ES3DV3 - SN:3292**

Calibration procedure(s): **QA CAL-01.v9, QA CAL-12.v9, QA CAL-23.v5, QA CAL-25.v6  
Calibration procedure for dosimetric E-field probes**

Calibration date: **January 25, 2023**

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 (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-22 (No. 217-02521/02522)	Apr-23
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-02521)	Apr-23
Power sensor NRP-Z91	SN: 103245	04-Apr-22 (No. 217-02525)	Apr-23
Reference 20 dB Attenuator	SN: 55277 (20x)	07-Apr-22 (No. 217-02528)	Apr-23
Reference Probe ES3DV2	SN: 3013	30-Dec-22 (No. ES3-3013, Dec17)	Dec-23
DAE4	SN: 660	21-Dec-22 (No. DAE4-660, Dec17)	Dec-23
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E44158	SN: GB41293874	06-Apr-22 (in house check Jun-16)	In house check: Jun-23
Power sensor E4412A	SN: MY41499087	06-Apr-22 (in house check Jun-16)	In house check: Jun-23
Power sensor E4412A	SN: 000110210	06-Apr-22 (in house check Jun-16)	In house check: Jun-23
RF generator HP 8648C	SN: US3642U01700	04-Aug-22 (in house check Jun-16)	In house check: Jun-23
Network Analyzer HP 8753E	SN: US37390585	22-Oct-01 (in house check Oct-17)	In house check: Oct-23

Calibrated by: **Jeton Kastrell** (Name), **Laboratory Technician** (Function), [Signature]

Approved by: **Katja Pokovic** (Name), **Technical Manager** (Function), [Signature]

Issued: January 25, 2022

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



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**S** Servizio svizzero di taratura  
**S** Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

#### 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 $\varphi$	$\varphi$ rotation around probe axis
Polarization $\theta$	$\theta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\theta = 0$ 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  $\theta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not affect the E<sup>2</sup>-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 with CW signal (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>; D<sub>x,y,z</sub>; VR<sub>x,y,z</sub>**: A, B, C, D 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  $f \leq 800$  MHz) and inside waveguide using analytical field distributions based on power measurements for  $f > 800$  MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values 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  $\pm 50$  MHz to  $\pm 100$  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).

#### Shenzhen Anbotek Compliance Laboratory Limited

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Hangcheng Street, Bao'an District, Shenzhen, Guangdong, China.

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Hotline  
400-003-0500  
www.anbotek.com

ES3DV3 – SN:3292

January 25, 2018

# Probe ES3DV3

## SN:3292

Manufactured: July 6, 2010  
Calibrated: January 25, 2023

**Calibrated for DASY/EASY Systems**  
(Note: non-compatible with DASY2 system!)

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ES3DV3- SN:3292

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3292

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	0.95	0.96	0.93	$\pm 10.1\%$
DCP (mV) <sup>B</sup>	104.2	107.6	112.3	

### Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc <sup>E</sup> (k=2)
0	CW	X	0.0	0.0	1.0	0.00	191.5	$\pm 3.3\%$
		Y	0.0	0.0	1.0		187.6	
		Z	0.0	0.0	1.0		190.2	

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%.

<sup>A</sup> The uncertainties of Norm X,Y,Z do not affect the E<sup>2</sup>-field uncertainty inside TSL (see Pages 5 and 6).  
<sup>B</sup> Numerical linearization parameter: uncertainty not required.  
<sup>E</sup> Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

ES3DV3- SN:3292

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3292

### 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)	Unc (k=2)
150	52.3	0.76	7.85	7.85	7.85	0.04	1.20	± 13.3 %
450	43.5	0.87	7.12	7.12	7.12	0.18	1.20	± 13.3 %

<sup>c</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the 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 frequencies 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 frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

ES3DV3- SN:3292

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3292

### Calibration Parameter Determined in Body 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)	Unc (k=2)
150	61.9	0.80	7.59	7.59	7.59	0.04	1.20	± 13.3 %
450	56.7	0.94	7.28	7.28	7.28	0.12	1.20	± 13.3 %

<sup>c</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the 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 frequencies 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 frequencies between 3-8 GHz at any distance larger than half the probe tip diameter from the boundary.

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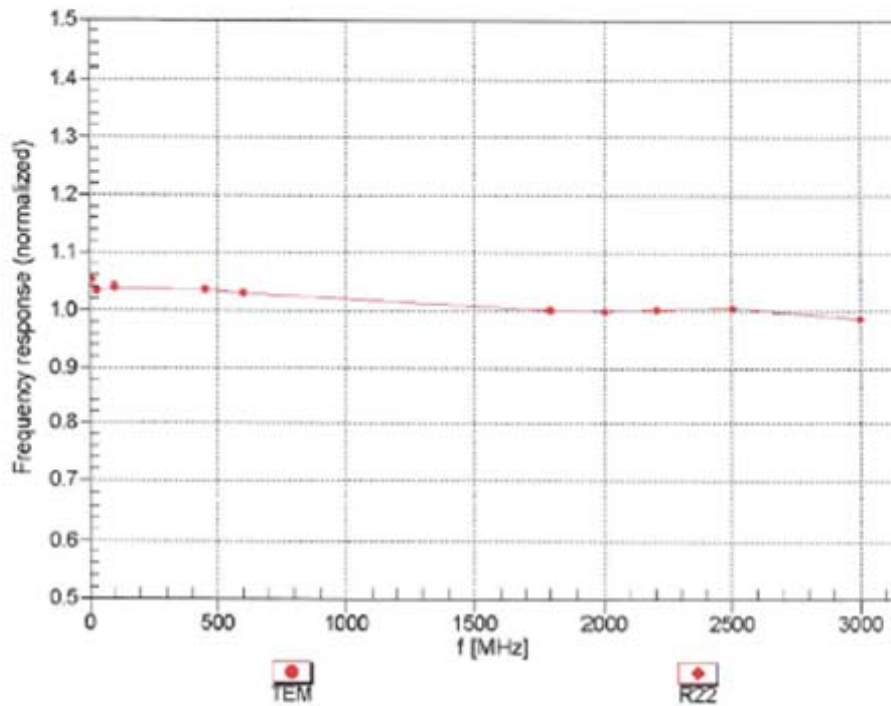
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ES3DV3- SN:3292

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



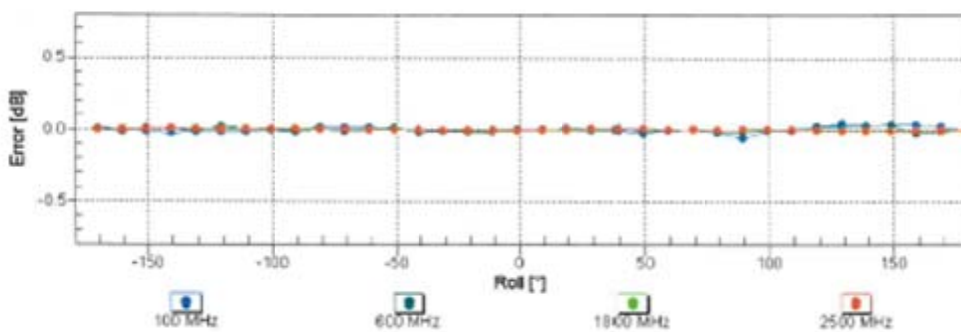
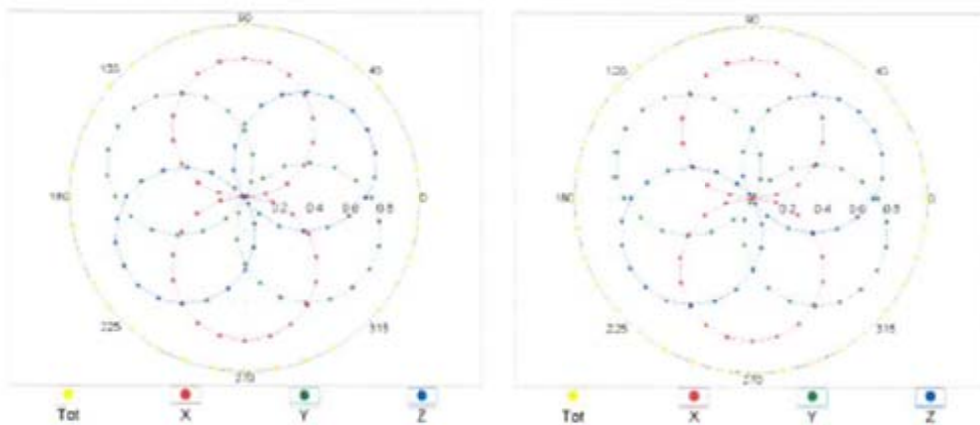
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

ES3DV3- SN:3292

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

f=600 MHz,TEM

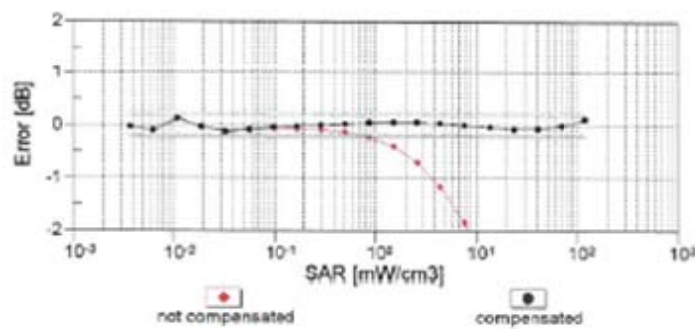
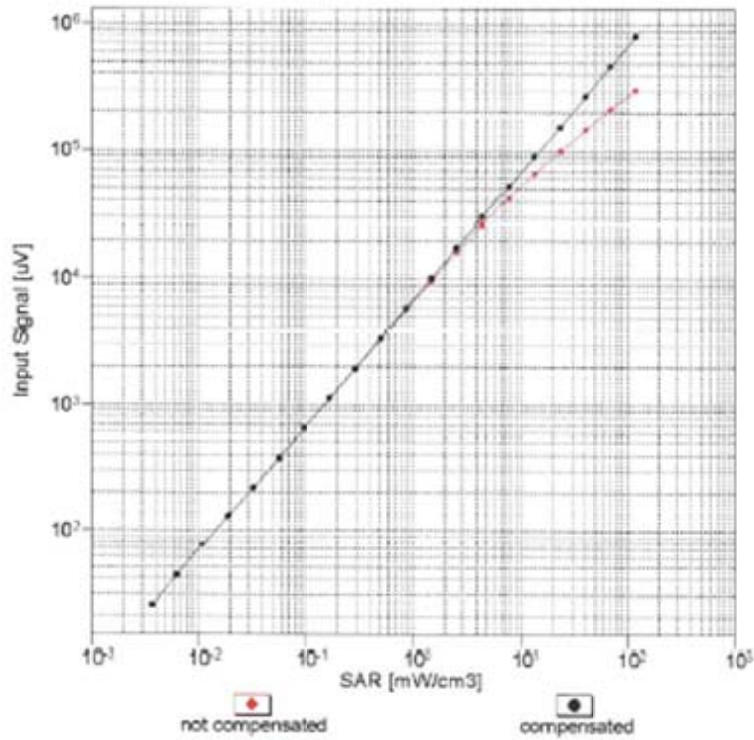
f=1800 MHz,R22



Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)

ES3DV3- SN:3292

**Dynamic Range f(SAR<sub>head</sub>)**  
(TEM cell , f<sub>eval</sub>= 1900 MHz)

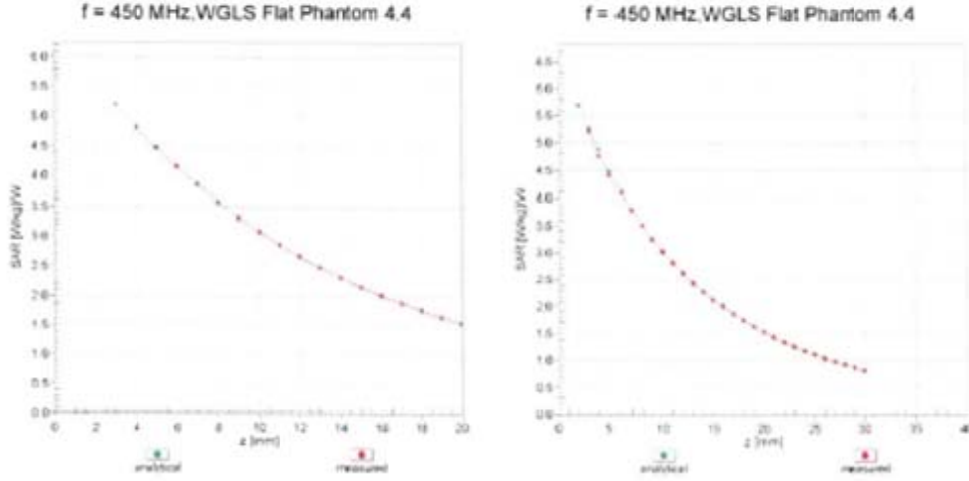


Uncertainty of Linearity Assessment: ± 0.6% (k=2)

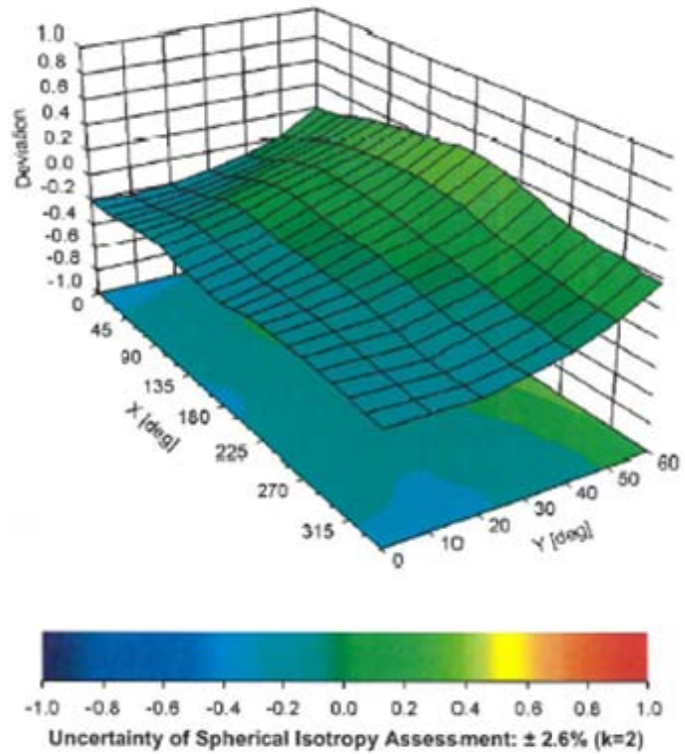


ES3DV3- SN:3292

### Conversion Factor Assessment



### Deviation from Isotropy in Liquid Error ( $\phi, \theta$ ), $f = 900$ MHz



ES3DV3- SN:3292

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3292

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	39.1
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	4 mm
Probe Tip to Sensor X Calibration Point	2 mm
Probe Tip to Sensor Y Calibration Point	2 mm
Probe Tip to Sensor Z Calibration Point	2 mm
Recommended Measurement Distance from Surface	3 mm

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## IMPORTANT NOTICE

### USAGE OF THE DAE 4

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

**Battery Exchange:** The battery cover of the DAE4 unit is closed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

**Shipping of the DAE:** Before shipping the DAE to SPEAG for calibration, remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts during transportation. The package shall be marked to indicate that a fragile instrument is inside.

**E-Stop Failures:** Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, the customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

**Repair:** Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

**DASY Configuration Files:** Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 MOhm is given in the corresponding configuration file.

**Important Note:**

**Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.**

**Important Note:**

**Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.**

**Important Note:**


**To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.**

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Accreditation No.: **SCS 0108**

Client **Anbotek (Auden)**

Certificate No: **DAE4-387\_Sep10**

**CALIBRATION CERTIFICATE**

Object: **DAE4 - SD 000 D04 BM - SN: 387**

Calibration procedure(s): **QA CAL-06.v29  
Calibration procedure for the data acquisition electronics (DAE)**

Calibration date: **September 06, 2022**

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 (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	15-Aug-22 (No:21092)	Aug-23
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	05-Jan-22 (in house check)	In house check: Jan-23
Calibrator Box V2.1	SE UMS 006 AA 1002	05-Jan-22 (in house check)	In house check: Jan-23

Calibrated by: **Dominique Steffen** (Laboratory Technician) [Signature]

Approved by: **Sven Kühn** (Deputy Manager) [Signature]

Issued: September 06, 2021

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Accreditation No.: **SCS 0108**

## 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 following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - **DC Voltage Measurement Linearity:** Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - **Common mode sensitivity:** Influence of a positive or negative common mode voltage on the differential measurement.
  - **Channel separation:** Influence of a voltage on the neighbor channels not subject to an input voltage.
  - **AD Converter Values with inputs shorted:** Values on the internal AD converter corresponding to zero input voltage
  - **Input Offset Measurement:** Output voltage and statistical results over a large number of zero voltage measurements.
  - **Input Offset Current:** Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - **Input resistance:** Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - **Low Battery Alarm Voltage:** Typical value for information. Below this voltage, a battery alarm signal is generated.
  - **Power consumption:** Typical value for information. Supply currents in various operating modes.

## Shenzhen Anbotek Compliance Laboratory Limited

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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	404.489 ± 0.02% (k=2)	404.852 ± 0.02% (k=2)	404.862 ± 0.02% (k=2)
Low Range	3.97827 ± 1.50% (k=2)	3.95875 ± 1.50% (k=2)	3.97982 ± 1.50% (k=2)

**Connector Angle**

Connector Angle to be used in DASY system	53.0 ° ± 1 °
---	--------------

**Appendix (Additional assessments outside the scope of SCS0108)**

**1. DC Voltage Linearity**

High Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	200032.85	-3.31	-0.00
Channel X + Input	20007.64	1.88	0.01
Channel X - Input	-20003.48	1.18	-0.01
Channel Y + Input	200034.23	-1.43	-0.00
Channel Y + Input	20006.60	0.91	0.00
Channel Y - Input	-20004.04	0.72	-0.00
Channel Z + Input	200035.38	-0.83	-0.00
Channel Z + Input	20003.69	-2.11	-0.01
Channel Z - Input	-20006.38	-1.59	0.01

Low Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	2001.63	0.08	0.00
Channel X + Input	202.29	0.70	0.35
Channel X - Input	-197.90	0.60	-0.30
Channel Y + Input	2001.33	-0.07	-0.00
Channel Y + Input	200.86	-0.60	-0.30
Channel Y - Input	-199.87	-1.23	0.62
Channel Z + Input	2001.61	0.27	0.01
Channel Z + Input	200.60	-0.70	-0.35
Channel Z - Input	-199.51	-0.85	0.43

**2. Common mode sensitivity**

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

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (μV)
Channel X	200	13.50	11.56
	-200	-8.64	-11.18
Channel Y	200	-0.81	-1.28
	-200	1.05	0.09
Channel Z	200	7.17	6.91
	-200	-9.46	-9.01

**3. Channel separation**

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

	Input Voltage (mV)	Channel X (μV)	Channel Y (μV)	Channel Z (μV)
Channel X	200	-	-1.70	0.33
Channel Y	200	10.70	-	-0.38
Channel Z	200	7.11	7.89	-

#### 4. AD-Converter Values with inputs shorted

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

	High Range (LSB)	Low Range (LSB)
Channel X	15969	17466
Channel Y	15661	16162
Channel Z	15990	16190

#### 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec  
Input 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	0.73	-2.58	3.29	0.62
Channel Y	0.41	-0.49	1.23	0.40
Channel Z	-0.80	-1.88	0.30	0.42

#### 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

#### 7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

#### 8. Low Battery Alarm Voltage (Typical values for information)

Typical values	Alarm Level (VDC)
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

#### 9. Power Consumption (Typical values for information)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	-0.01	-8	-9



**Calibration Laboratory of Schmid & Partner Engineering AG**  
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**S** Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)  
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **CIQ-SZ (Auden)**

Certificate No: **D450V3-1079\_Aug19**

**CALIBRATION CERTIFICATE**

Object **D450V3 - SN: 1079**

Calibration procedure(s) **QA CAL-15.v8  
Calibration procedure for dipole validation kits below 700 MHz**

Calibration date: **August 29, 2022**

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 (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	06-Apr-19 (No. 217-02288/02289)	Apr-21
Power sensor NRP-Z91	SN: 103244	06-Apr-19 (No. 217-02288)	Apr-21
Power sensor NRP-Z91	SN: 103245	06-Apr-19 (No. 217-02289)	Apr-21
Reference 20 dB Attenuator	SN: 5277 (20x)	05-Apr-19 (No. 217-02293)	Apr-21
Type-N mismatch combination	SN: 5047.2 / 06327	05-Apr-19 (No. 217-02295)	Apr-21
Reference Probe ET3DV6	SN: 1507	31-Dec-18 (No. ET3-1507_Dec18)	Dec-21
DAE4	SN: 654	12-Aug-19 (No. DAE4-654_Aug16)	Aug-21
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293674	06-Apr-18 (No. 217-02285/02284)	In house check: Jun-22
Power sensor E4412A	SN: MY41498087	06-Apr-18 (No. 217-02285)	In house check: Jun-22
Power sensor E4412A	SN: 000110210	06-Apr-18 (No. 217-02284)	In house check: Jun-22
RF generator HP 8648C	SN: US3642U01700	04-Aug-18 (in house check Jun-18)	In house check: Jun-22
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-18)	In house check: Oct-22

	<b>Name</b>	<b>Function</b>	<b>Signature</b>
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: August 30, 2022

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

**Calibration Laboratory of  
Schmid & Partner  
Engineering AG**  
Zeughausstrasse 43, 8004 Zurich, Switzerland



**S** Schweizerischer Kalibrierdienst  
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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

**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) 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
- b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- c) 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
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

- e) 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%.

### Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	ELI4 Flat Phantom	Shell thickness: $2 \pm 0.2$ mm
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	450 MHz $\pm$ 1 MHz	

### Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	43.5	0.87 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	44.3 $\pm$ 6 %	0.89 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °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	1.16 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	4.58 W/kg $\pm$ 18.1 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	0.775 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	3.06 W/kg $\pm$ 17.6 % (k=2)

### Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	56.7	0.94 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	56.7 $\pm$ 6 %	0.95 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	1.16 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	4.60 W/kg $\pm$ 18.1 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	0.764 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	3.03 W/kg $\pm$ 17.6 % (k=2)

**Appendix (Additional assessments outside the scope of SCS 0108)**

**Antenna Parameters with Head TSL**

Impedance, transformed to feed point	58.0 Ω - 2.9 jΩ
Return Loss	- 22.0 dB

**Antenna Parameters with Body TSL**

Impedance, transformed to feed point	56.1 Ω - 5.8 jΩ
Return Loss	-22.0 dB

**General Antenna Parameters and Design**

Electrical Delay (one direction)	1.348 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
Manufactured on	March 03, 2011

**DASY5 Validation Report for Head TSL**

Date: 29.08.2019

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 450 MHz; Type: D450V3; Serial: D450V3 - SN: 1079**

Communication System: UID 0 - CW; Frequency: 450 MHz

Medium parameters used:  $f = 450$  MHz;  $\sigma = 0.89$  S/m;  $\epsilon_r = 44.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

**DASY52 Configuration:**

- Probe: ET3DV6 - SN1507; ConvF(6.58, 6.58, 6.58); Calibrated: 31.12.2018;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn654; Calibrated: 12.08.2019
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1003
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Head Tissue/d=15mm, Pin=250mW/Zoom Scan (7x7x7)/Cube 0:**

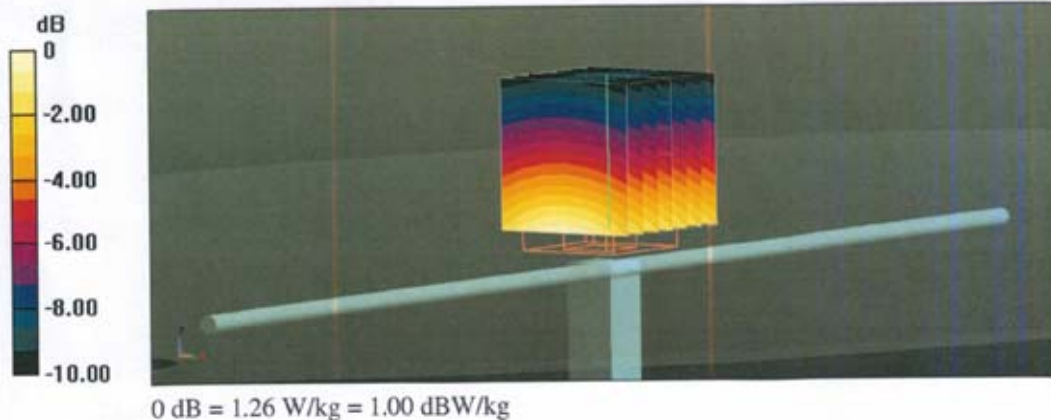
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 39.87 V/m; Power Drift = -0.05 dB

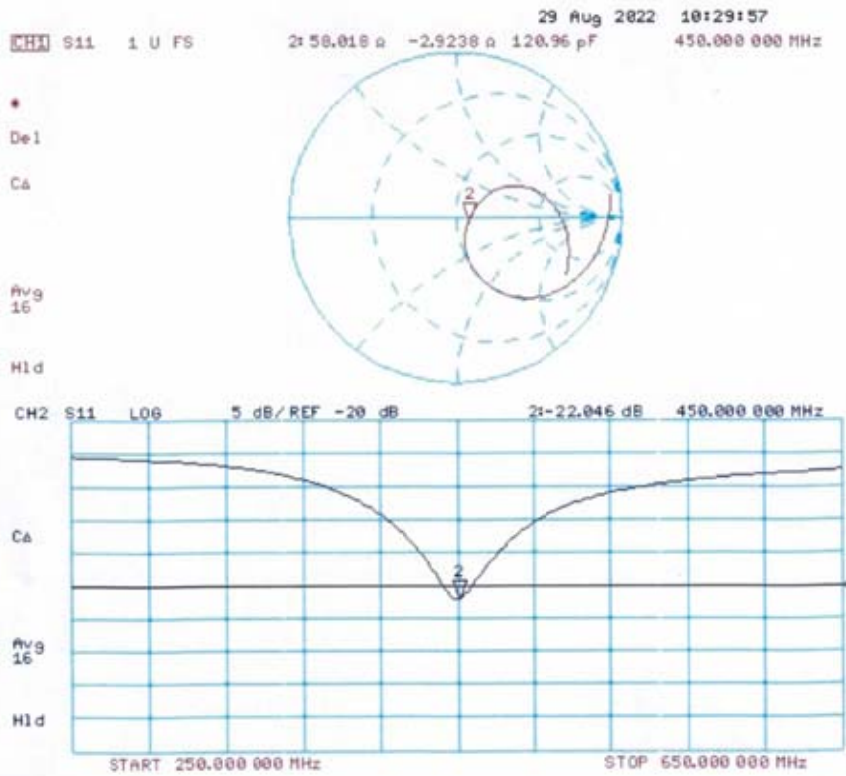
Peak SAR (extrapolated) = 1.69 W/kg

**SAR(1 g) = 1.16 W/kg; SAR(10 g) = 0.775 W/kg**

Maximum value of SAR (measured) = 1.26 W/kg



**Impedance Measurement Plot for Head TSL**



**DASY5 Validation Report for Body TSL**

Date: 29.08.2022

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 450 MHz D450V3; Type: D450V3; Serial: D450V3 - SN:1079**

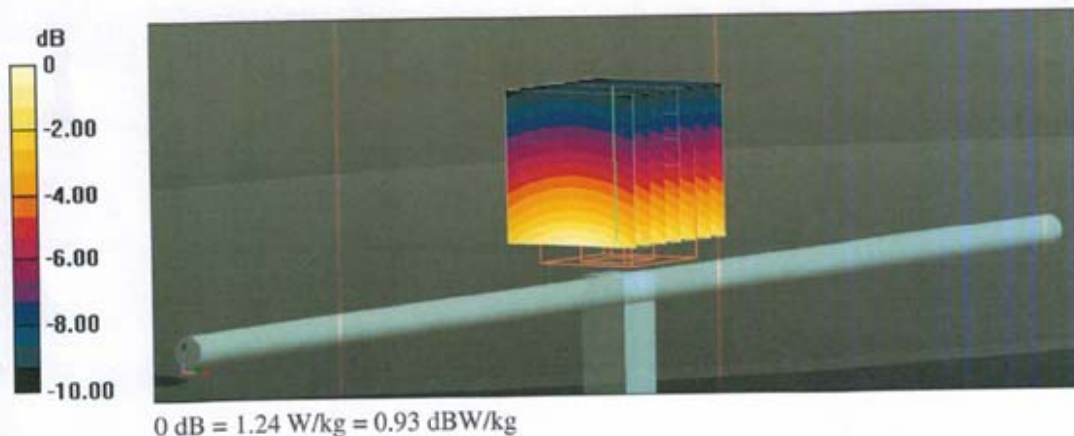
Communication System: UID 0 - CW; Frequency: 450 MHz  
Medium parameters used:  $f = 450 \text{ MHz}$ ;  $\sigma = 0.95 \text{ S/m}$ ;  $\epsilon_r = 56.7$ ;  $\rho = 1000 \text{ kg/m}^3$   
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

**DASY52 Configuration:**

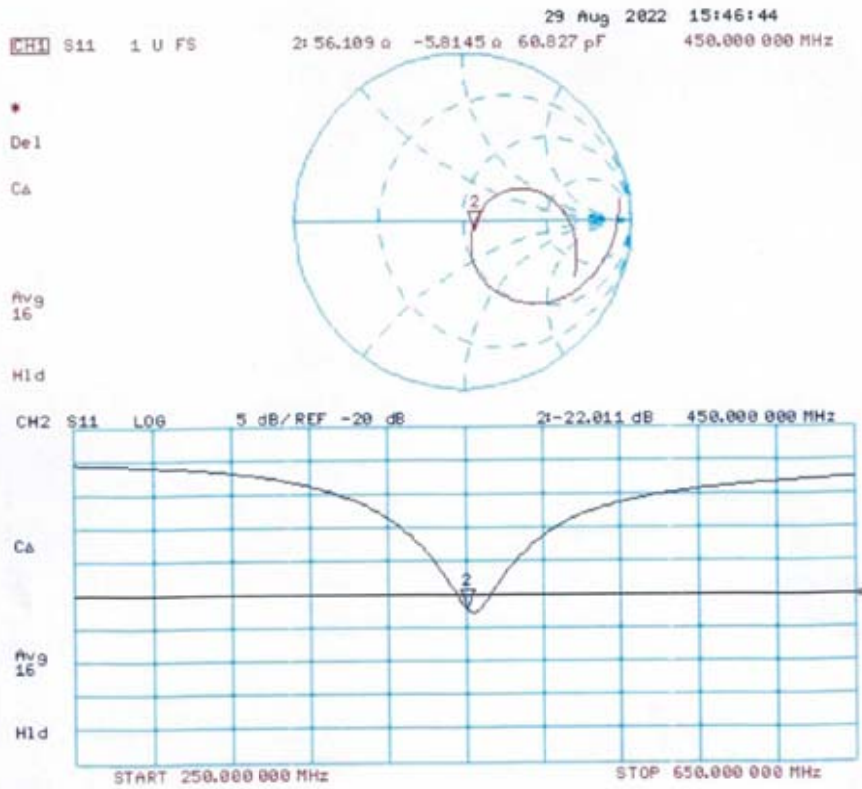
- Probe: ET3DV6 - SN1507; ConvF(6.99, 6.99, 6.99); Calibrated: 31.12.2018;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn654; Calibrated: 12.08.2019
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1003
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Body Tissue/d=15mm, Pin=250mW/Zoom Scan (7x7x7)/Cube 0:**

Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$   
Reference Value = 37.17 V/m; Power Drift = -0.01 dB  
Peak SAR (extrapolated) = 1.82 W/kg  
**SAR(1 g) = 1.16 W/kg; SAR(10 g) = 0.764 W/kg**  
Maximum value of SAR (measured) = 1.24 W/kg



### Impedance Measurement Plot for Body TSL





**\*\*\*\*\*END OF REPORT\*\*\*\*\***

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