# FCC SAR Test Report

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|---|---|---|
| **Report No.** | : | **ES210407003W02** |
| **Applicant** | : | **Shenzhen Hui Ke Electronics Co., LTD.** |
| **Address** | : | **Room A, 2 Floor, 5 Building, Hezhou Yuye Industrial park, Xixiang, Baoan District, Shenzhen,China** |
| **EUT** | : | **Walkie talkie** |
| **Model No.** | : | **HK-001,HK-002,HK-003,T-388,HK-188,HK-288, HK-588,HK-688,HK-888,HK-988,HK-005,HK-006** |
| **Trade mark** | : | **N/A** |
| **Standards** | : | **FCC 47 CFR Part 2 § 2.1093:2013**<br>**IEEE Std C95.1™ -2005**<br>**IEC 62209-1:2016**<br>**IEEE Std. 1528:2013** |
| **Date of Testing** | : | **Apr.22, 2021** |

**CERTIFICATION:**The above equipment have been tested by **EMTEK (SHENZHEN) CO., LTD.Bldg 69, Majialong Industry Zone,Nanshan District, Shenzhen, Guangdong, China**,and found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's SAR characteristics under the conditions specified in this report.This report shall not be reproduced, except in full, without the written approval ofEMTEK (SHENZHEN) CO., LTD.

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# Release ControlRecord

| Report No. | Reason for Change | Date Issued |
|---|---|---|
| ES210407003W02 | Initial release | May.20, 2021 |
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# 1. Summary of Maximum SAR Value

| Operating Mode | Highest $SAR_{1g}$(W/kg) (corrected by Multiplying 50%) |
|---|---|
| **Analog** | **Face up: 0.303 W/kg**<br>**Body-Back: 0.510 W/kg** |

**Note:**

1. The SAR limit **(Head & Body: $SAR_{1g}$1.6 W/kg, Extremity: $SAR_{10g}$ 4.0 W/kg)**for general population/uncontrolled exposure is specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1992.

## 2. Description of Equipment Under Test

| | |
|---|---|
| Product: | Walkie talkie |
| Model Number: | HK-001,HK-002,HK-003,T-388,HK-188,HK-288,HK-588,HK-688, HK-888,HK-988,HK-005,HK-006<br>(These models are identical in circuitry and electrical, mechanical and physical construction; Only the appearance is different; We chose HK-001 as the final test prototype) |
| Power supply: | DC6V by 4pcs replaceable AAA battry |
| Frequency Range: | 462.5625MHz |
| Type of Modulation: | F3E |
| Channel Spacing: | 12.5kHz |
| Max Transmit Power: | 26.74 dBm |
| Antenna: | Inseparable antenna |
| Antenna Gain: | 0.5 dBi |

**Note:**

1. The above EUT information is declared by manufacturer and for more detailed features description please refers to the manufacturer's specifications or User's Manual.

# 3. SAR Measurement System

## 3.1 Definition of SpecificAbsorptionRate (SAR)

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.

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 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 the tissue and E is the RMS electrical field strength.

## 3.2 SPEAG DASY System

DASY system consists of high precision robot, probe alignment sensor, phantom, robot controller, controlled measurement server and near-field probe. The robot includes six axes that can move to the precision position of the DASY5 software defined. The DASYsoftware can define the area that is detected by the probe. The robot is connected to controlled box. Controlled measurement server is connected to the controlled robot box. The DAE includes amplifier, signal multiplexing, AD converter, offset measurement and surface detection. It is connected to the Electro-optical coupler (ECO). The ECO performs the conversion form the optical into digital electric signal of the DAE and transfers data to the PC.

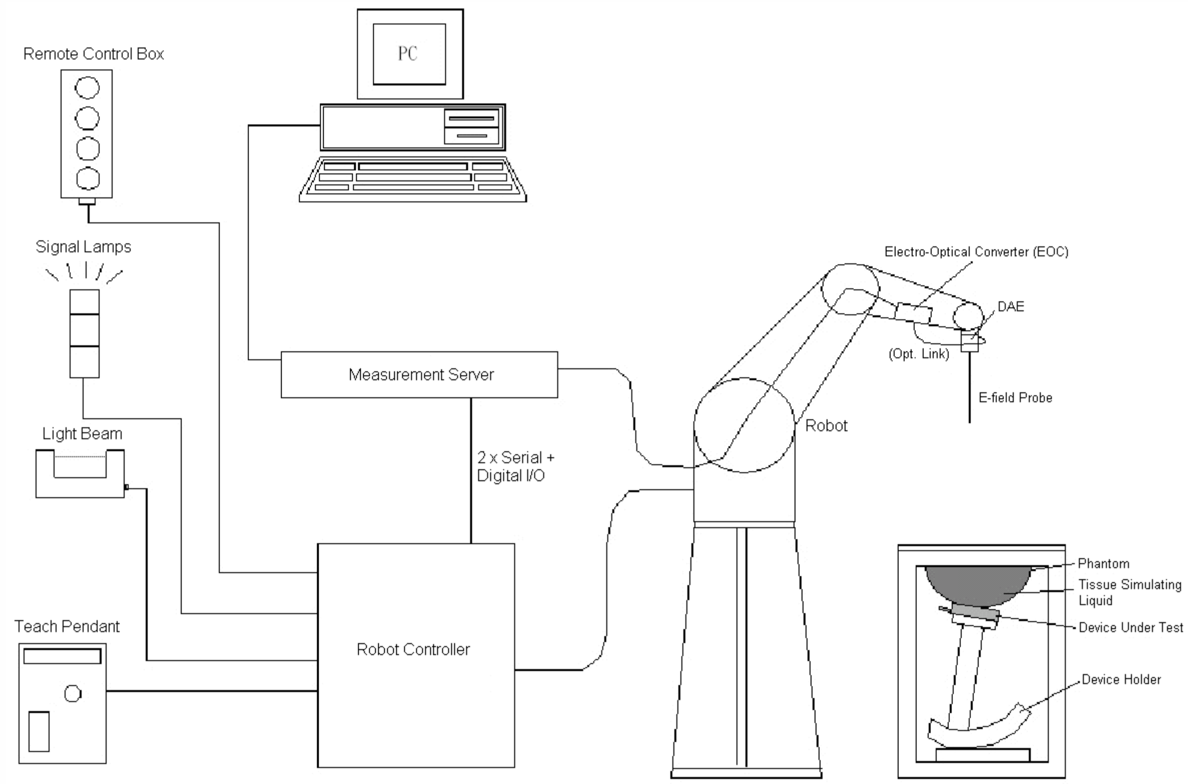



**Fig-3.1 DASY System Setup**

## Robot

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

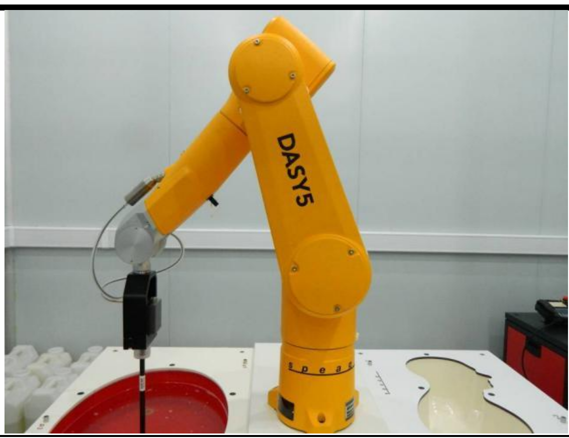



**Fig-3.2 DASY5**

Access to the World

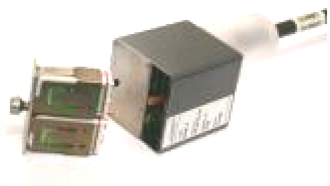
**Probes**

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

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

| **Model** | ES3DV3 |  |
|---|---|---|
| **Construction** | Symmetrical design with triangular core. Interleaved sensors. Built-in shielding against static charges. PEEK enclosure material (resistant to organic solvents, e.g., DGBE). | |
| **Frequency** | 10 MHz to 4 GHz<br>Linearity: ± 0.2 dB | |
| **Directivity** | ± 0.2 dB in HSL (rotation around probe axis)<br>± 0.3 dB in tissue material (rotation normal to probe axis) | |
| **Dynamic Range** | 5 µW/g to 100 mW/g<br>Linearity: ± 0.2 dB | |
| **Dimensions** | Overall length: 337 mm (Tip: 20 mm)<br>Tip diameter: 3.9 mm (Body: 12 mm)<br>Distance from probe tip to dipole centers: 2.0 mm | |

**Data Acquisition Electronics (DAE)**

| **Model** | DAE3, DAE4 |  |
|---|---|---|
| **Construction** | Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop. | |
| **Measurement Range** | -100 to +300 mV (16 bit resolution and two range settings: 4mV, 400mV) | |
| **Input Offset Voltage** | < 5µV (with auto zero) | |
| **Input Bias Current** | < 50 fA | |
| **Dimensions** | 60 x 60 x 68 mm | |

**Phantoms**

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

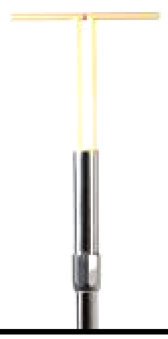
| Model | ELI |  |
|---|---|---|
| Construction | Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its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

## Device Holder

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

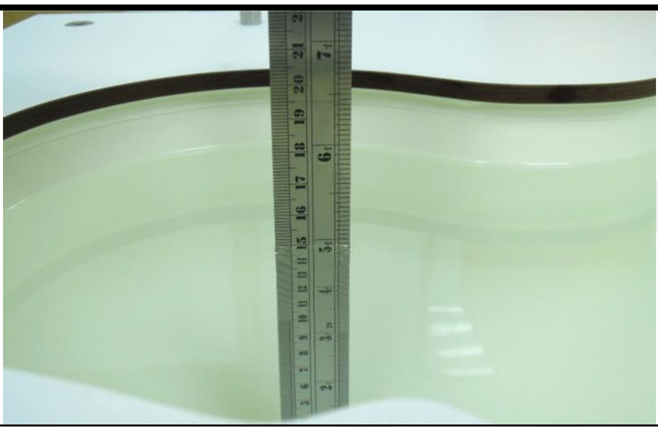
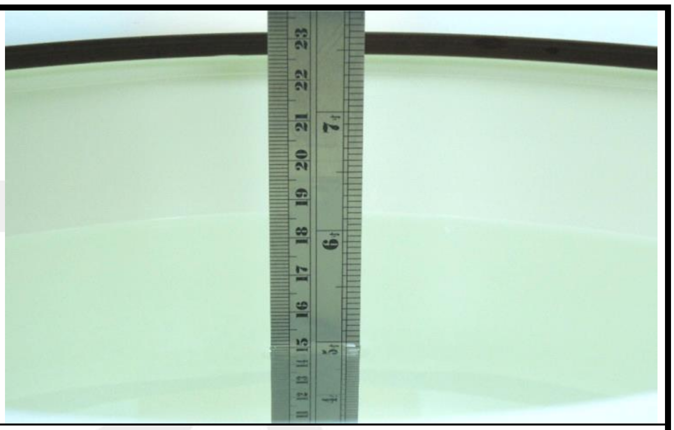
| | | |
|---|---|---|
| **Model** | Laptop Extensions Kit |  |
| **Construction** | Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices according to IEC 62209-2 (e.g., laptops, cameras, etc.). It is lightweight and fits easily on the upper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

## System Validation Dipoles

| | | |
|---|---|---|
| **Model** | D-Serial |  |
| **Construction** | Symmetrical dipole with l/4 balun. Enables measurement of feedpoint impedance with NWA. Matched for use near flat phantoms filled with tissue simulating solutions. | |
| **Frequency** | 750 MHz to 5800 MHz | |
| **Return Loss** | > 20 dB | |
| **Power Capability** | > 100 W (f < 1GHz),> 40 W (f > 1GHz) | |

**Tissue Simulating Liquids**

For SAR measurement of the field distribution inside the phantom, the phantom must be filled with homogeneous tissue simulating liquid to a depth of at least 15 cm.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. The nominal dielectric values of the tissue simulating liquids in the phantom and the tolerance of 5% are listed in Table-3.1.

| | |
|---|---|
|  |  |
| **Photo of Liquid Height for Head Position** | **Photo of Liquid Height for Body Position** |

The dielectric properties of the tissue simulating liquids are defined in IEC 62209-1 and IEC62209-2. The dielectric properties of the tissue simulating liquids were verified prior to the SAR evaluation using a dielectric assessment kit and a network analyzer.

**Table-3.1Targets of Tissue Simulating Liquid**

| Frequency (MHz) | Target Permittivity | Range of ±5% | Target Conductivity | Range of ±5% |
|---|---|---|---|---|
| 450 | 43.5 | 41.3 ~ 45.7 | 0.87 | 0.83 ~ 0.91 |
| 750 | 41.9 | 39.8 ~ 44.0 | 0.89 | 0.85 ~ 0.93 |
| 835 | 41.5 | 39.4 ~ 43.6 | 0.90 | 0.86 ~ 0.95 |
| 900 | 41.5 | 39.4 ~ 43.6 | 0.97 | 0.92 ~ 1.02 |
| 1450 | 40.5 | 38.5 ~ 42.5 | 1.20 | 1.14 ~ 1.26 |
| 1640 | 40.3 | 38.3 ~ 42.3 | 1.29 | 1.23 ~ 1.35 |
| 1750 | 40.1 | 38.1 ~ 42.1 | 1.37 | 1.30 ~ 1.44 |
| 1800 | 40.0 | 38.0 ~ 42.0 | 1.40 | 1.33 ~ 1.47 |
| 1900 | 40.0 | 38.0 ~ 42.0 | 1.40 | 1.33 ~ 1.47 |
| 2000 | 40.0 | 38.0 ~ 42.0 | 1.40 | 1.33 ~ 1.47 |
| 2300 | 39.5 | 37.5 ~ 41.5 | 1.67 | 1.59 ~ 1.75 |
| 2450 | 39.2 | 37.2 ~ 41.2 | 1.80 | 1.71 ~ 1.89 |
| 2600 | 39.0 | 37.1 ~ 41.0 | 1.96 | 1.86 ~ 2.06 |
| 3500 | 37.9 | 36.0 ~ 39.8 | 2.91 | 2.76 ~ 3.06 |
| 5200 | 36.0 | 34.2 ~ 37.8 | 4.66 | 4.43 ~ 4.89 |
| 5300 | 35.9 | 34.1 ~ 37.7 | 4.76 | 4.52 ~ 5.00 |
| 5500 | 35.6 | 33.8 ~ 37.4 | 4.96 | 4.71 ~ 5.21 |
| 5600 | 35.5 | 33.7 ~ 37.3 | 5.07 | 4.82 ~ 5.32 |
| 5800 | 35.3 | 33.5 ~ 37.1 | 5.27 | 5.01 ~ 5.53 |

## 3.3 SAR System Verification

The system check verifies that the system operates within its specifications. It is performed daily or before every SAR measurement. The system check uses normal SAR measurements in the flat section of the phantom with a matched dipole at a specified distance. The system verification setup is shown as below.

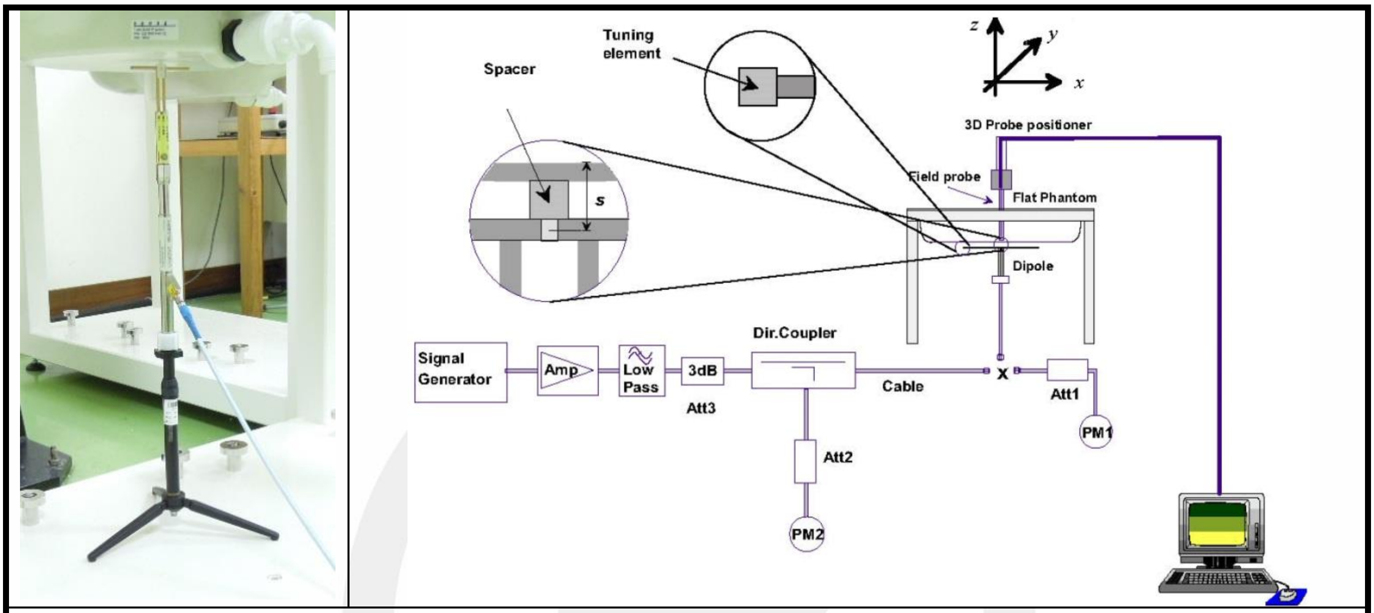



**Fig-3.3System Verification Setup**

The validation dipole is placed beneath the flat phantom with the specific spacer in place. The distance spacer is touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The spectrum analyzer measures the forward power at the location of the system check dipole connector. The signal generator is adjusted for the desired forward power (250 mW is used for 700 MHz to 3 GHz, 100 mW is used for 3.5 GHz to 6 GHz) at the dipole connector and the power meter is read at that level. After connecting the cable to the dipole, the signal generator is readjusted for the same reading at power meter.

After system check testing, the SAR result will be normalized to 1W forward input power and compared with the reference SAR value derived from validation dipole certificate report. The deviation of system check should be within 10 %.

## 3.4 SAR Measurement Procedure

According to the SAR 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

The SAR measurement procedures for each of test conditions are as follows:

(a) Make EUT to transmit maximum output power
(b) Measure Transmitter outputpower through RF cable
(c) Place the EUT in the specific position of phantom
(d) Perform SAR testing steps on the DASY system
(e) Record the SAR value

**Area & Zoom Scan Procedure**

First Area Scan is used to locate the approximate location(s) of the local peak SAR value(s). The measurement grid within an Area Scan is defined by the grid extent, grid step size and grid offset. Next, in order to determine the EM field distribution in a three-dimensional spatial extension, Zoom Scan is required. The Zoom Scan measures 5x5x7 points with step size 8, 8 and 5 mm for below 3 GHz, 5x5x7 points with step size 6, 6 and 4 mm for 3 GHz to 4 GHz, and 7x7x12 points with step size 4, 4 and 2 mm for above 5 GHz. The Zoom Scan is performed around the highest E-field value to determine the averaged SAR-distribution over 10 g.

**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.

**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 form 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

**SAR Averaged Methods**

In DASY, the interpolation and extrapolation are both based on the modified Quadratic Shepard's method. The interpolation scheme combines a least-square fitted function method and a weighted average method which are the two basic types of computational interpolation and approximation.

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. The uncertainty increases with the extrapolation distance. To keep the uncertainty within 1% for the 1 g and 10 g cubes, the extrapolation distance should not be larger than 5 mm.

# 4. SAR Measurement Evaluation

## 4.1 EUT Configuration and Setting

**< Test Positions for front-of-face configurations >**

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. 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 body-worn and other configurations>**

Body-worn operating configurations should be tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in normal use configurations. Devices with a headset output should be tested with a headset connected to the device. When multiple accessories that do not contain metallic components are supplied with the device, the device may be tested with only the accessory that dictates the closest spacing to the body. When multiple accessories that contain metallic components are supplied with the device, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component (e.g., the same metallic belt-clip used with different holsters with no other metallic components), only the accessory that dictates the closest spacing to the body must be tested. Body-worn accessories may not always be supplied or available as options for some devices that are intended to be authorized for body-worn use. A separation distance of 1.5 cm between the back of the device and a flat phantom is recommended for testing body-worn SAR compliance under such circumstances. Other separation distances may be used, but they should not exceed 2.5 cm. In these cases,the device may use body-worn accessories that provide a separation distance greater than that tested for the device provided however that the accessory contains no metallic components.

## 4.2 EUT Testing Position

**Body-worn device**

A typical example of a body-worn device is a Walkie talkie, wireless enabled PDA or other battery operated wireless device with the ability to transmit while mounted on a person’s body using a carry accessory approved by the wireless device manufacturer.

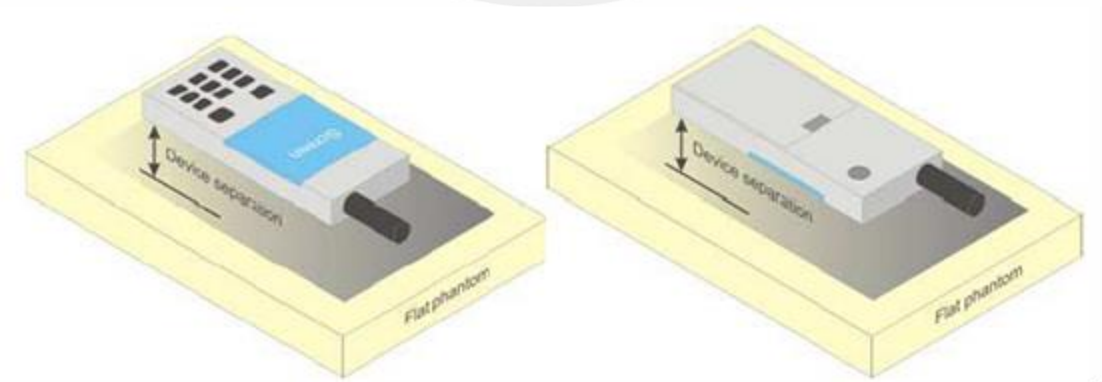



**Fig-4.1 Illustration for Walkie talkie Setup**

EUT Setup Photos

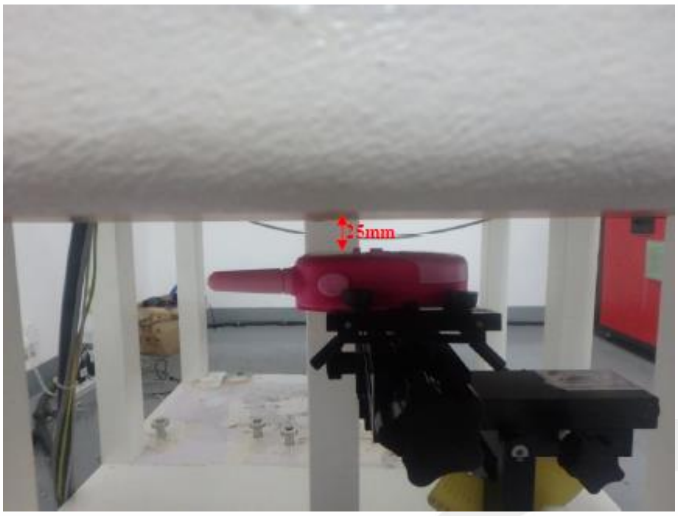



Fig-4.1 Face up of EUT with 25 mm Gap

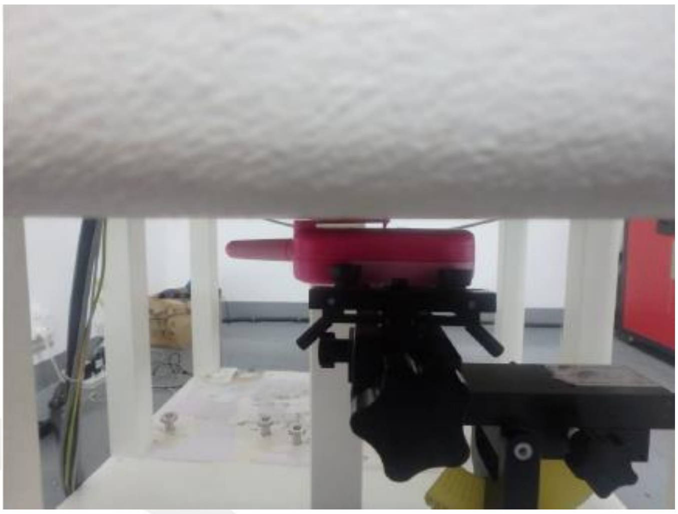


Fig-4.2 Body back of EUT with 0 cm Gap(with Belt Clip)

## 4.3 Tissue Verification

The measuring results for tissue simulating liquid are shown as below.

| Tissue Type | Frequency (MHz) | Measured Conductivity (σ) | Measured Permittivity ($\varepsilon_r$) | Target Conductivity (σ) | Target Permittivity ($\varepsilon_r$) | Conductivity Deviation (%) | Permittivity Deviation (%) | Test Date |
|---|---|---|---|---|---|---|---|---|
| H450 | 450 | 0.86 | 43.51 | 0.87 | 43.5 | -1.15 | 0.02 | Apr.22, 2021 |

**Note:**

1. The dielectric properties of the tissue simulating liquid must be measured within 24 hours before the SAR testing and within ±5% of the target values. Liquid temperature during the SAR testing must be within ±2 ℃.
2. Since the maximum deviation of dielectric properties of the tissue simulating liquid is within 5%, SAR correction is evaluated in the measurement uncertainty shown on section 6 of this report.

## 4.4 System Verification

The measuring results for system check are shown as below.

| Test Date | Frequency (MHz) | 1W Target SAR-1g (W/kg) | Measured SAR-1g (W/kg) | Normalized to1W SAR-1g (W/kg) | Deviation (%) | Dipole S/N | Probe S/N | DAE S/N |
|---|---|---|---|---|---|---|---|---|
| Apr.22, 2021 | 450 | 4.61 | 0.302 | 4.79 | 3.90 | 1113 | 3337 | 1398 |

**Note:**

Comparing to the reference SAR value provided by SPEAG, the validation data should be within its specification of 10 %. The result indicates the system check can meet the variation criterion and the plots can be referred to Appendix A of this report.

## 4.5 Power Measurement

| Frequency (MHz) | Channel | ERP (dBm) |
|---|---|---|
| 462.5625-462.7125MHz(0.5W) | | |
| 462.5625 | 1 | 26.74 |

## 4.6 SAR Testing Results

**SAR Test Results Summary**

UHF(High Power)

| SAR MEASUREMENT | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth of Liquid (cm):>15 | | | | | Relative Humidity (%): 51.4 | | | | |
| Product: Walkie Talkie | | | | | | | | | |
| Test Mode: Hold to Face with 2.5 cm separation & body back touch with clip | | | | | | | | | |
| **Position** | **Freq. (MHz)** | **Separation (KHz)** | **Power Drift (±0.2dB)** | **SAR 1g with 100% duty Cycle (W/kg)** | **SAR 1g with 50% duty cycle (W/kg)** | **Max. Tune-up Power (dBm)** | **Meas. output Power (dBm)** | **Scaled SAR (W/kg)** | **Limit W/kg** |
| Analog | | | | | | | | | |
| Face Up | 462.5625 | 12.5 | -0.36 | 0.526 | 0.263 | 26.99 | 26.74 | 0.303 | 1.6 |
| Back Touch +Belt Clip | 462.5625 | | -0.48 | 0.862 | 0.431 | 26.99 | 26.74 | 0.510 | 1.6 |

Note:

1. During the test, EUT power is 0.5 W with 100% duty cycle;
2. There is just default battery and antenna in this project;
3. $\text{Max\_ Scaled} = SAR\_meas * 10^{\frac{-Drift}{10}} * \frac{P\_max}{P\_int} * DC$

P_ max = Maximum Power(W)
P_ int = Initial Power(W)
Drift = DASY drift results(dB)
SAR_ meas=Measured 10-g or 1-g Avg.SAR(W/kg)
DC = Transmission mode duty cycle in % where applicable 50% duty cycle is applied for PTT operation.
For conservative results, the following are applied:
If P_ int > P_ max, then P_ max/P_ int =1. Drift = 1 for positive drift

| Repeated SAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Product: Walkie Talkie | | | | | | | | |
| Test Mode: body back touch with clip | | | | | | | | |
| **Position** | **Frequency (MHz)** | **Separation (KHz)** | **Power Drift (<±0.2dB)** | **Once SAR 1g with 100% duty cycle (W/kg)** | **Once SAR 1g with 50% duty cycle (W/kg)** | **Twice SAR 1g with 100% duty cycle (W/kg)** | **Twice SAR 1g with 50% duty cycle (W/kg)** | **Limit W/kg** |
| Back Tou | 462.5625 75 | 12.5 | -0.17 | 0.662 | -- | -- | -- | 1.6 |

All test data are from **A**ttestation of **G**lobal **C**ompliance(Shenzhen) Co.,Ltd
**Test Engineer：** Jack Gui

# 5. Calibration of Test Equipment

| Equipment description | Manufacturer/ Model | Identification No. | Current calibration date | Next calibration date |
|---|---|---|---|---|
| Stäubli Robot | Stäubli-TX60 | F13/5Q2UD1/A/01 | N/A | N/A |
| Robot Controller | Stäubli-CS8 | 139522 | N/A | N/A |
| E-Field Probe | Speag- ES3DV3 | SN:3337 | Sep. 08,2020 | Sep. 07,2021 |
| ELI4 Phantom | ELI V5.0 | 1210 | N/A | N/A |
| Device Holder | Speag-SD 000 H01 KA | SD 000 H01 KA | N/A | N/A |
| DAE4 | Speag-SD 000 D04 BM | 1398 | Apr. 23,2020 | Apr. 22,2021 |
| SAR Software | Speag-DASY5 | DASY52.8.7.1137 | N/A | N/A |
| Liquid | SATIMO | - | N/A | N/A |
| Dipole | Speag-D450V3 | SN:1113 | Feb. 05,2021 | Feb. 04,2024 |
| Signal Generator | Agilent-E4438C | US41461365 | Aug. 21,2020 | Aug. 20,2021 |
| Vector Analyzer | Agilent / E4440A | US41421290 | Sep. 06,2020 | Sep. 05,2021 |
| Network Analyzer | Rhode & Schwarz ZVL6 | SN101443 | Oct. 16,2020 | Oct. 15,2021 |
| Attenuator | Warison /WATT-6SR1211 | S/N:WRJ34AYM2F1 | June 10,2020 | June 09,2021 |
| Amplifier | AS0104-55_55 | 1004793 | June 11,2020 | June 10,2021 |
| Directional Couple | Werlatone/ C5571-10 | SN99463 | May 15,2020 | May 14,2022 |
| Power Sensor | NRP-Z21 | 1137.6000.02 | Sep. 08,2020 | Sep. 07,2021 |
| Power Sensor | NRP-Z23 | 100323 | Feb. 17,2021 | Feb. 16,2022 |
| Power Viewer | R&S | V2.3.1.0 | N/A | N/A |

## 6. Measurement Uncertainty

The component of uncertainly may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainly by the statistical analysis of a series of observations is termed a Type An evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience, and knowledge of the behavior and properties of relevant materials and instruments, manufacture's specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in Table as follow.

| Uncertainty Distributions | Normal | Rectangular | Triangular | U-Shape |
|---|---|---|---|---|
| Multi-plying Factor(a) | 1/k(b) | $1/\sqrt{3}$ | $1/\sqrt{6}$ | $1/\sqrt{2}$ |

(a) Standard uncertainty is determined as the product of the multiplying factor and the estimated range of variations in the measured quantity

(b) $\kappa$ is the coverage factor

**Table 13.1 Standard Uncertainty for Assumed Distribution (above table)**

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual "root-sum-squares" (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is shown in the following tables.

| DASY Uncertainty- ES3DV3<br>Measurement uncertainty for DUT averaged over 1 gram / 10 gram. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Uncertainty Component | Sec. | Tol (± %) | Prob. Dist. | Div. | Ci (1g) | Ci (10g) | 1g Ui (±%) | 10g Ui (±%) | vi |
| **Measurement System** | | | | | | | | | |
| Probe calibration | Annex B | 6.65 | N | 1 | 1 | 1 | 6.65 | 6.65 | ∞ |
| Axial Isotropy | 7.2.2.2 | 0.25 | R | √3 | √0.5 | √0.5 | 0.10 | 0.10 | ∞ |
| Hemispherical Isotropy | 7.2.2.2 | 1.30 | R | √3 | √0.5 | √0.5 | 0.53 | 0.53 | ∞ |
| Boundary effect | 7.2.2.5 | 1.00 | R | √3 | 1 | 1 | 0.58 | 0.58 | ∞ |
| Linearity | 7.2.2.3 | 0.30 | R | √3 | 1 | 1 | 0.17 | 0.17 | ∞ |
| System detection limits | 7.2.2.3 | 1.00 | R | √3 | 1 | 1 | 0.58 | 0.58 | ∞ |
| Modulation response | 7.2.2.4 | 3.30 | R | √3 | 1 | 1 | 1.91 | 1.91 | ∞ |
| Readout Electronics | 7.2.2.6 | 0.15 | N | 1 | 1 | 1 | 0.15 | 0.15 | ∞ |
| Response Time | 7.2.2.7 | 0.00 | R | √3 | 1 | 1 | 0.00 | 0.00 | ∞ |
| Integration Time | 7.2.2.8 | 1.70 | R | √3 | 1 | 1 | 0.98 | 0.98 | ∞ |
| RF ambient conditions-Noise | 7.2.9 | 3.00 | R | √3 | 1 | 1 | 1.73 | 1.73 | ∞ |
| RF ambient conditions-reflections | 7.2.9 | 3.00 | R | √3 | 1 | 1 | 1.73 | 1.73 | ∞ |
| Probe positioner mechanical tolerance | 7.2.3.1 | 0.40 | R | √3 | 1 | 1 | 0.23 | 0.23 | ∞ |
| Probe positioning with respect to phantom shell | 7.2.3.2 | 6.70 | R | √3 | 1 | 1 | 3.87 | 3.87 | ∞ |
| Post-processing | 7.2.10 | 4.00 | R | √3 | 1 | 1 | 2.31 | 2.31 | ∞ |
| **Test sample Related** | | | | | | | | | |
| Test sample positioning | 7.2.5.3 | 2.90 | N | 1 | 1 | 1 | 2.90 | 2.90 | ∞ |
| Device holder uncertainty | 7.2.5.2 | 3.60 | N | 1 | 1 | 1 | 3.60 | 3.60 | ∞ |
| SAR drift measurement | 7.2.8 | 5.00 | R | √3 | 1 | 1 | 2.89 | 2.89 | ∞ |
| SAR scaling | 7.2.11 | 5.00 | R | √3 | 1 | 1 | 2.89 | 2.89 | ∞ |
| **Phantom and set-up** | | | | | | | | | |
| Phantom uncertainty ( shape and thickness uncertainty ) | 7.2.4 | 6.60 | R | √3 | 1 | 1 | 3.81 | 3.81 | ∞ |
| Uncertainty in SAR correction for deviations in permittivity and conductivity | 7.2.7.2 | 1.90 | N | 1 | 1 | 0.84 | 1.90 | 1.60 | ∞ |
| Liquid conductivity ( temperature uncertainty ) | 7.2.6.6<br>7.2.6.5 | 2.50 | R | √3 | 0.78 | 0.71 | 1.13 | 1.02 | ∞ |
| Liquid conductivity ( measured ) | 7.2.6.3<br>7.2.6.5 | 4.00 | N | 1 | 0.78 | 0.71 | 3.12 | 2.84 | M |
| Liquid permittivity ( temperature uncertainty ) | 7.2.6.6<br>7.2.6.5 | 2.50 | R | √3 | 0.23 | 0.26 | 0.33 | 0.38 | ∞ |
| Liquid permittivity ( measured ) | 7.2.6.4<br>7.2.6.5 | 5.00 | N | 1 | 0.23 | 0.26 | 1.15 | 1.30 | M |
| Combined Standard Uncertainty | | | RSS | | | | 11.79 | 11.62 | |
| Expanded Uncertainty (95% Confidence interval) | | | K=2 | | | | 23.58 | 23.25 | |

| DASY Uncertainty- ES3DV3<br>System validation uncertainty for Dipole averaged over 1 gram / 10 gram. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Uncertainty Component | Sec. | Tol (±%) | Prob. Dist. | Div. | Ci (1g) | Ci (10g) | 1g Ui (±%) | 10g Ui (±%) | vi |
| **Measurement System** | | | | | | | | | |
| Probe calibration | Annex B | 6.65 | N | 1 | 1 | 1 | 6.65 | 6.65 | ∞ |
| Axial Isotropy | 7.2.2.2 | 0.25 | R | √3 | 1 | 1 | 0.14 | 0.14 | ∞ |
| Hemispherical Isotropy | 7.2.2.2 | 1.30 | R | √3 | 0 | 0 | 0.00 | 0.00 | ∞ |
| Boundary effect | 7.2.2.5 | 1.00 | R | √3 | 1 | 1 | 0.58 | 0.58 | ∞ |
| Linearity | 7.2.2.3 | 0.30 | R | √3 | 1 | 1 | 0.17 | 0.17 | ∞ |
| System detection limits | 7.2.2.3 | 1.00 | R | √3 | 1 | 1 | 0.58 | 0.58 | ∞ |
| Modulation response | 7.2.2.4 | 3.30 | R | √3 | 0 | 0 | 0.00 | 0.00 | ∞ |
| Readout Electronics | 7.2.2.6 | 0.15 | N | 1 | 1 | 1 | 0.15 | 0.15 | ∞ |
| Response Time | 7.2.2.7 | 0.00 | R | 1 | 0 | 0 | 0.00 | 0.00 | ∞ |
| Integration Time | 7.2.2.8 | 1.70 | R | √3 | 0 | 0 | 0.00 | 0.00 | ∞ |
| RF ambient conditions-Noise | 7.2.9 | 3.00 | R | √3 | 1 | 1 | 1.73 | 1.73 | ∞ |
| RF ambient conditions-reflections | 7.2.9 | 3.00 | R | √3 | 1 | 1 | 1.73 | 1.73 | ∞ |
| Probe positioner mechanical tolerance | 7.2.3.1 | 0.40 | R | √3 | 1 | 1 | 0.23 | 0.23 | ∞ |
| Probe positioning with respect to phantom shell | 7.2.3.2 | 6.70 | R | √3 | 1 | 1 | 3.87 | 3.87 | ∞ |
| Post-processing | 7.2.10 | 4.00 | R | √3 | 1 | 1 | 2.31 | 2.31 | ∞ |
| **System validation source** | | | | | | | | | |
| Deviation of experimental dipole from numerical dipole | 7.2.12 | 5.00 | N | 1 | 1 | 1 | 5.00 | 5.00 | ∞ |
| Input power and SAR drift measurement | 7.2.8 | 5.00 | R | √3 | 1 | 1 | 2.89 | 2.89 | ∞ |
| Other source contribution Uncertainty | 7.2.13 | 2.00 | R | √3 | 1 | 1 | 1.15 | 1.15 | ∞ |
| **Phantom and set-up** | | | | | | | | | |
| Phantom uncertainty ( shape and thickness uncertainty ) | 7.2.4 | 6.60 | R | √3 | 1 | 1 | 3.81 | 3.81 | ∞ |
| Uncertainty in SAR correction for deviations in permittivity and conductivity | 7.2.7.2 | 1.90 | N | 1 | 1 | 0.84 | 1.90 | 1.60 | ∞ |
| Liquid conductivity ( temperature uncertainty ) | 7.2.6.6<br>7.2.6.5 | 2.50 | R | √3 | 0.78 | 0.71 | 1.13 | 1.02 | ∞ |
| Liquid conductivity ( measured ) | 7.2.6.3<br>7.2.6.5 | 4.00 | N | 1 | 0.78 | 0.71 | 3.12 | 2.84 | M |
| Liquid permittivity ( temperature uncertainty ) | 7.2.6.6<br>7.2.6.5 | 2.50 | R | √3 | 0.23 | 0.26 | 0.33 | 0.38 | ∞ |
| Liquid permittivity ( measured ) | 7.2.6.4<br>7.2.6.5 | 5.00 | N | 1 | 0.23 | 0.26 | 1.15 | 1.30 | M |
| Combined Standard Uncertainty | | | RSS | | | | 11.44 | 11.27 | |
| Expanded Uncertainty (95% Confidence interval) | | | K=2 | | | | 22.88 | 22.54 | |

| DASY Uncertainty- ES3DV3<br>System Check uncertainty for Dipole averaged over 1 gram / 10 gram. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Uncertainty Component | Sec. | Tol (± %) | Prob. Dist. | Div. | Ci (1g) | Ci (10g) | 1g Ui (±%) | 10g Ui (±%) | vi |
| **Measurement System** | | | | | | | | | |
| Probe calibration drift | Table 13 note a | 0.50 | N | 1 | 1 | 1 | 0.50 | 0.50 | ∞ |
| Axial Isotropy | 7.2.2.2 | 0.25 | R | $\sqrt{3}$ | 0 | 0 | 0.00 | 0.00 | ∞ |
| Hemispherical Isotropy | 7.2.2.2 | 1.30 | R | $\sqrt{3}$ | 0 | 0 | 0.00 | 0.00 | ∞ |
| Boundary effect | 7.2.2.5 | 1.0 | R | $\sqrt{3}$ | 0 | 0 | 0.00 | 0.00 | ∞ |
| Linearity | 7.2.2.3 | 0.3 | R | $\sqrt{3}$ | 0 | 0 | 0.00 | 0.00 | ∞ |
| System detection limits | 7.2.2.3 | 0.30 | R | $\sqrt{3}$ | 0 | 0 | 0.00 | 0.00 | ∞ |
| Modulation response | 7.2.2.4 | 1.00 | R | $\sqrt{3}$ | 0 | 0 | 0.00 | 0.00 | ∞ |
| Readout Electronics | 7.2.2.6 | 3.30 | N | 1 | 0 | 0 | 0.00 | 0.00 | ∞ |
| Response Time | 7.2.2.7 | 0.15 | R | $\sqrt{3}$ | 0 | 0 | 0.00 | 0.00 | ∞ |
| Integration Time | 7.2.2.8 | 0.00 | R | $\sqrt{3}$ | 0 | 0 | 0.00 | 0.00 | ∞ |
| RF ambient conditions-Noise | 7.2.9 | 1.70 | R | $\sqrt{3}$ | 0 | 0 | 0.00 | 0.00 | ∞ |
| RF ambient conditions-reflections | 7.2.9 | 3.00 | R | $\sqrt{3}$ | 0 | 0 | 0.00 | 0.00 | ∞ |
| Probe positioner mechanical tolerance | 7.2.3.1 | 3.00 | R | $\sqrt{3}$ | 1 | 1 | 0.23 | 0.23 | ∞ |
| Probe positioning with respect to phantom shell | 7.2.3.2 | 0.40 | R | $\sqrt{3}$ | 1 | 1 | 3.87 | 3.87 | ∞ |
| Post-processing | 7.2.10 | 6.70 | R | $\sqrt{3}$ | 0 | 0 | 0.00 | 0.00 | ∞ |
| **System check source** | | | | | | | | | |
| Deviation between experimental dipoles | 7.2.12 | 2.00 | N | 1 | 1 | 1 | 2.00 | 2.00 | ∞ |
| Input power and SAR drift measurement | 7.2.8 | 5.00 | R | $\sqrt{3}$ | 1 | 1 | 2.89 | 2.89 | ∞ |
| Other source contribution Uncertainty | 7.2.13 | 2.00 | R | $\sqrt{3}$ | 1 | 1 | 1.15 | 1.15 | ∞ |
| **Phantom and set-up** | | | | | | | | | |
| Phantom uncertainty ( shape and thickness uncertainty ) | 7.2.4 | 6.60 | R | $\sqrt{3}$ | 1 | 1 | 3.81 | 3.81 | ∞ |
| Uncertainty in SAR correction for deviations in permittivity and conductivity | 7.2.7.2 | 1.90 | N | 1 | 1 | 0.84 | 1.90 | 1.60 | ∞ |
| Liquid conductivity ( temperature uncertainty ) | 7.2.6.6<br>7.2.6.5 | 2.50 | R | $\sqrt{3}$ | 0.78 | 0.71 | 1.13 | 1.02 | ∞ |
| Liquid conductivity ( measured ) | 7.2.6.3<br>7.2.6.5 | 4.00 | N | 1 | 0.78 | 0.71 | 3.12 | 2.84 | M |
| Liquid permittivity ( temperature uncertainty ) | 7.2.6.6<br>7.2.6.5 | 2.50 | R | $\sqrt{3}$ | 0.23 | 0.26 | 0.33 | 0.38 | ∞ |
| Liquid permittivity ( measured ) | 7.2.6.4<br>7.2.6.5 | 5.00 | N | 1 | 0.23 | 0.26 | 1.15 | 1.30 | M |
| Combined Standard Uncertainty | | | RSS | | | | 9.89 | 9.69 | |
| Expanded Uncertainty (95% Confidence interval) | | | K=2 | | | | 19.78 | 19.38 | |

# 7. Information on the Testing Laboratories

**TEST FACILITY**

We, EMTEK (SHENZHEN) CO., LTD., were founded in 2000 to provide our best service in EMC, Radio, Telecom and Safety consultation. Our laboratories are accredited and approved according to ISO/IEC 17025.

Site Description
EMC Lab. : **Accredited by CNAS**
The Certificate Registration Number is L2291.
The Laboratory has been assessed and proved to be in compliance with CNAS-CL01 (identical to ISO/IEC 17025:2017)

**Accredited by FCC**
Designation Number: CN1204
Test Firm Registration Number: 882943

**Accredited by A2LA**
The Certificate Number is 4321.01.

**Accredited by Industry Canada**
The Conformity Assessment Body Identifier is CN0008

Name of Firm : EMTEK (SHENZHEN) CO., LTD.
Site Location : Building 69, Majialong Industry Zone, Nanshan District, Shenzhen, Guangdong, China

If you have any comments, please feel free to contact us at the following:

Add:Bldg 69, Majialong Industry Zone, Nanshan District, Shenzhen, Guangdong, China
TEL: 86-755-26954280
FAX: 86-755-26954282
**Email:** csg@emtek.com.cn
**Web Site:** www.emtek.com.cn

The road map of all our labs can be found in our web site also.

**---END---**

# Appendix A. SAR Plots of System Verification

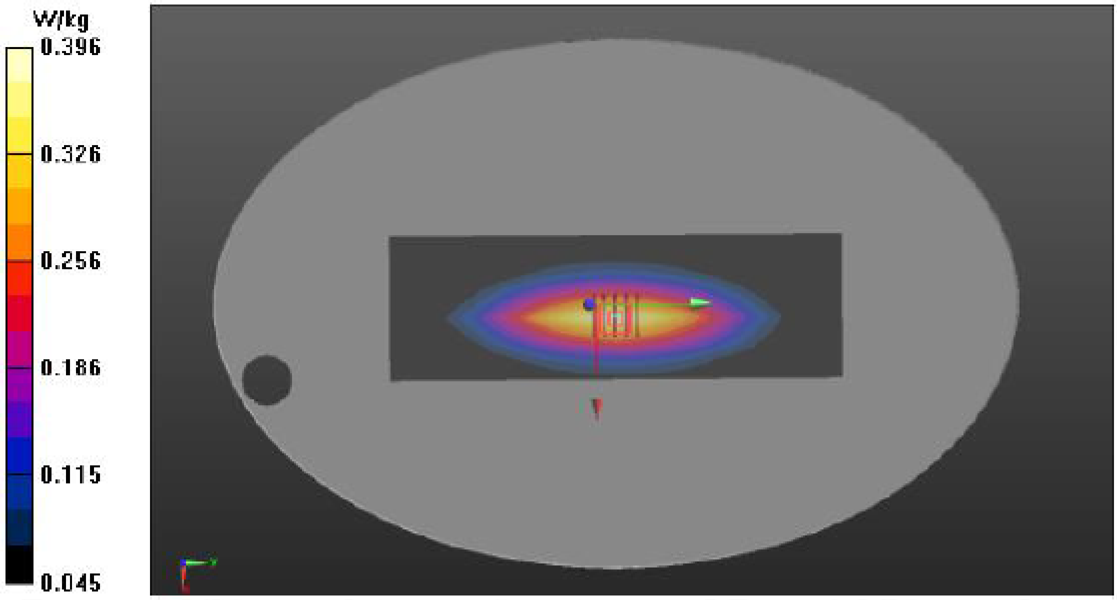
The plots for system verificationwith largest deviation for each SAR system combination are shown as follows.

**Test Laboratory: AGC Lab** **Test date: Apr. 22,2021**
**System Check 450MHz**
**DUT: Dipole 450 MHz Type: D450V3**
Communication System: CW; Communication System Band: D450(450.0 MHz); Duty Cycle: 1:1;
Frequency: 450MHz; Medium parameters used: f = 450MHz; σ= 0.86 mho/m; εr =43.51; ρ = 1000 kg/m³ ;
Phantom Type: Elliptical Phantom; Input Power=18dBm
Ambient temperature (℃): 21.7, Liquid temperature (℃): 21.4

DASY Configuration:
•Probe:ES3DV3 – SN3337; ConvF(6.93, 6.93, 6.93); Calibrated: Sep. 08,2020;
•Sensor-Surface: 3mm (Mechanical Surface Detection), z = 1.0,
•Electronics: DAE4 SN1398; Calibrated: Apr. 23,2020
•Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1108
•DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

**Configuration/System Check 450MHz Head/Area Scan (8x23x1):** Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 0.399 W/kg

**Configuration/System Check 450MHz Head/Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 19.884 V/m; Power Drift = -0.17 dB
Peak SAR (extrapolated) = 0.531 W/kg
**SAR(1 g) = 0.302 W/kg; SAR(10 g) = 0.201 W/kg**
Maximum value of SAR (measured) = 0.396 W/kg



# Appendix B. SAR Plots of SAR Measurement

The SAR plots for highest measured SAR in each exposure configuration, wireless mode and frequency band combination are shown as follows.

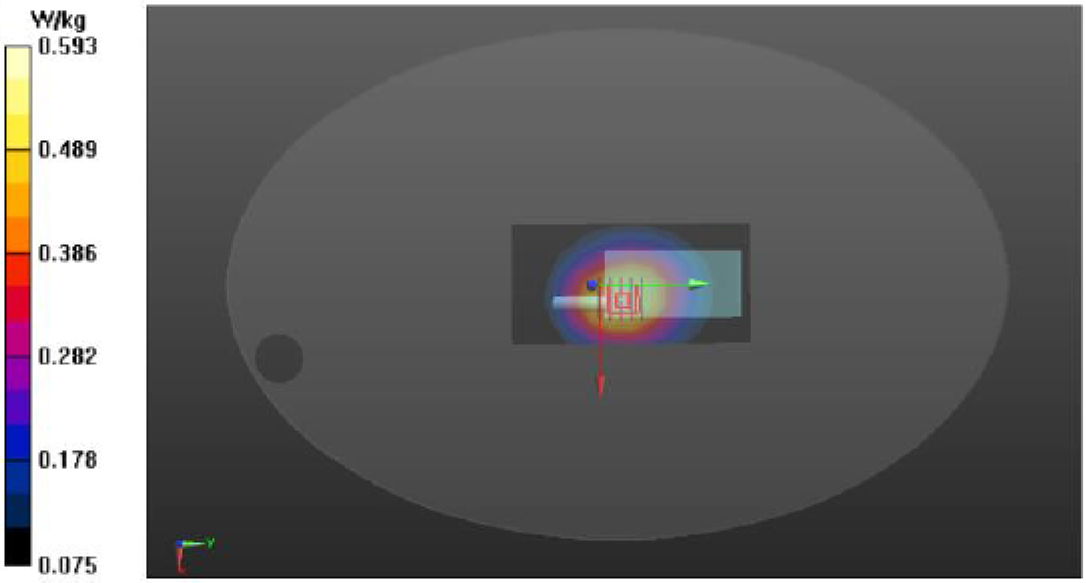
**Test Laboratory: AGC Lab** **Date: Apr. 22,2021**
**450 face up 2.5cm (12.5 KHz)**
**DUT: Walkie Talkie; Type: HK-001**

Communication System: 450; Communication System Band: D450 (450.0 MHz); Duty Cycle: 1:1;
Frequency:462.5625 MHz; Medium parameters used: f = 450MHz; σ= 0.88 mho/m; εr =42.69; ρ= 1000 kg/m³ ;
Phantom Type: Elliptical Phantom
Ambient temperature (℃): TAPA2, Liquid temperature (℃): 21.4

DASY Configuration:
- Probe:ES3DV3 – SN3337; ConvF(6.93, 6.93, 6.93); Calibrated: Sep. 08,2020;
- Sensor-Surface: 3mm (Mechanical Surface Detection), z = 1.0,
- Electronics: DAE4 SN1398; Calibrated: Apr. 23,2020
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1108
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

**FACE UP/A-12.5K-FACE UP/Area Scan (7x13x1):** Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 0.596 W/kg

**FACE UP/A-12.5K-FACE UP/Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 26.191 V/m; Power Drift = -0.36 dB
Peak SAR (extrapolated) = 0.756 W/kg
**SAR(1 g) = 0.526 W/kg; SAR(10 g) = 0.375 W/kg**
Maximum value of SAR (measured) = 0.593 W/kg



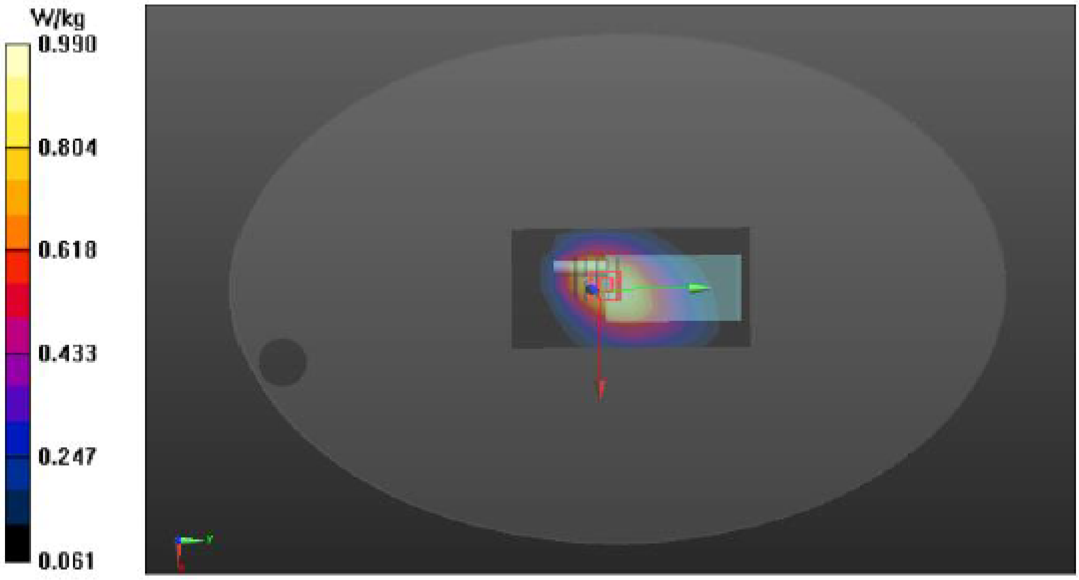
**Test Laboratory: AGC Lab** **Date: Apr. 22,2021**
**450 Body –Touch (12.5 KHz)**
**DUT: Walkie Talkie; Type: HK-001**

Communication System: 450; Communication System Band: D450 (450.0 MHz); Duty Cycle: 1:1;
Frequency:462.5625 MHz; Medium parameters used: f = 450 MHz; σ= 0.88 mho/m; εr =42.69; ρ= 1000 kg/m ;
Phantom Type: Elliptical Phantom
Ambient temperature (℃): TAPA2, Liquid temperature (℃): 21.4

DASY Configuration:
- Probe:ES3DV3 – SN3337; ConvF(6.93, 6.93, 6.93); Calibrated: Sep. 08,2020;
- Sensor-Surface: 3mm (Mechanical Surface Detection), z = 1.0,
- Electronics: DAE4 SN1398; Calibrated: Apr. 23,2020
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1108
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

**BODY/A-12.5K-BACK/Area Scan (7x13x1):** Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 1.05 W/kg

**BODY/A-12.5K-BACK/Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 37.733 V/m; Power Drift = -0.48 dB
Peak SAR (extrapolated) = 1.44 W/kg
**SAR(1 g) = 0.862 W/kg; SAR(10 g) = 0.589 W/kg**
Maximum value of SAR (measured) = 0.990 W/kg



## Appendix C. Calibration Certificate for Probe and Dipole

The calibration certificates are shown as follows.